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PHYSIOLOGICAL CHANGES INDUCED BY *FARINOCYSTIS TRIBOLII* WEISER IN THE LARVAE OF *TRIBOLIUM CASTANEUM* (HERBST)

R. J. RABINDRA, M. BALASUBRAMANIAN & S. JAYARAJ

Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, India 641 003

(Received 28 June 1987)

The total carbohydrates and glycogen in *Farinocystis tribolii* Weiser-infected larvae of *Tribolium castaneum* (Herbst) were significantly lower than in healthy larvae, due to depletion by parasites actively multiplying in the fat body. The total nitrogen and uric acid levels were, however, significantly higher in diseased than in healthy larvae. The increased amount of uric acid found in infected insects may be the result of breakdown of fat body protein by the pathogens. Sodium, potassium, and total phosphorus contents were higher in diseased than in healthy larvae. As the disease progressed, the potassium content in the diseased larvae increased steadily and on the 10th day, the increase in potassium content over healthy larvae was 76 per cent.

(Keywords: Farinocystis tribolii, Tribolium castaneum, biochemicel changes, carbohydrates, glycogen, total nitrogen, uric acid, minerals)

INTRODUCTION

The Neogregarine, *Farinocystis tribolii* Weiser is an important parasite of larvae of the red flour beetle, *Tribolium castaneum* (Herbst) destroying the fat bodies (RABINDRA *et al.*, 1981). All the larval instars were susceptible although 100 per cent mortality was recorded in the older larvae, the LT_{50} was prolonged (RABINDRA et al., 1983). The biochemical changes due to the deranged metabolism caused by *F. tribolii* in larvae of *T. castaneum* were investigated and the changes in total carbohydrates, glycogen, total nitrogen, uric acid and minerals are discussed in this paper.

MATERIALS AND METHODS

The rearing of host larvae, multiplication and preparation of *F. tribolii* spores for inoculation were done following the methods described earlier (RABINDRA *et al.*, 1981). Fourth instar larvae of uniform age within 12 h of moult were starved for 8 h and inoculated with *F. tribolii* by allowing the larvae to feed for 24 h on wheat flour containining 10^8 spores/g. Three samples of larvae of 500 mg each were drawn at random every 48 h upto 10 days from each treated and untreated groups and starved for 8 h before analysis. The estimations were done on whole larval homogenates. Carbohydrates and glycogen were extracted from fresh samples in ice-cold 0 3 N perchloric acid (CROMPTON & BIRT, 1967) and estimated by the modified anthrone method of FAIRBRAIN (1953). Total carbohydrates were determined colorimetrically using pure glucose (BDH) as the standard.

Glycogen was precipitated from the acid extract by the addition of four volumes of 95% ethyl alcohol by the method of ROE *et al.*, (1961), centrifuged to sediment the pellet which was dried in a dessicator over calcium chloride and dissolved in a known volume of distilled water and the glycogen estimated colorimetrically using pure glycogen (BDH) as the standard.

Total nitrogen was estimated in 50 mg dry samples by the micro-kjeldahl method of JACKSON (1962). Uric acid was extracted from 25 mg samples of dry prowdered materials (MORAN, 1959) and estimated colorimetrically using uric acid (BDH) as the standard (BROWN, 1945).

To estimate the sodium, potassium and phosphorus contents, 200 mg of dry powdered samples were digested with 10 ml of ternary acid mixture consisting of nitric acid, perchloric acid and sulphuric acid in the proportion of 10:1:4 (V/V) till the acid extract became clear and colourless. The extract was then made upto 50 ml. Sodium and potassium were estimated by the method of JACKSON (1962) using an EEL flame photometer. For estimation of total phosphorus, the vanado molybdate method of JACKSON (1962) was used.

The data were subjected to analysis of variance and the means separated by L S D.

RESULTS AND DISCUSSION

The total carbohydrates in healthy larvae increased with age whereas, in *F. tribolii*-infected larvae, it decreased as the infection progressed and the levels were significantly lower than in healthy larvae from the 4th day onwards (Table 1). Similarly, the glycogen content in healthy larvae also increased with age in contrast to a drastic reduction in infected larave (Table 2). The depletion of glycogen in infected larvae is reflected in the total carbohydrate content, SCHWALBE et al. (1973) compared the glycogen levels of healthy and *Mattesia trogodermae* Canning-infected larvae of *Trogoderma glabrum* (Herbst) and found that infected insects showed a drastic depletion of glycogen in *M. trogodermae*-infected larvae.

RABINDRA et al. (1981) found that *F. tribolii* multiplied in the fat tissue and definite signs of damage to the fat cells were noticed on the fourth day of infection when some of the fat cells had collapsed to accommodate the schizonts. This period corresponds to the time when the depletion of carbohydrates and glycogen was beginning to be observed in the present investigations. As the infection progressed, the fat tissues were destroyed and by eighth day of infection they were completely depleted. Obviously, the depletion of carbohydrates and glycogen in diseased larvae observed in the present study was due to the active multiplication of the parasites in the fat body. According to KILBY (1963), glycogen is readily synthesised by fat body from sugars like glucose, fructose, sucrose and maltose and that both glycolysis and tricarboxylic acid cycles are operative in the fat body. The pathogen by destroying the fat body might have interfered with the synthesis of glycogen, a major fraction of the carbohydrates.

The diseased insects had significantly higher total nitrogen (Table 3) and uric acid (Table 4) levels from fourth day onwards. The higher nitrogen content in infected larvae is obviously due to the increased amounts of uric acid. Uric acid is formed as an end product of protein and purine catabolism in insects (CHEFURKA, 1965). The increased amounts of uric acid found in infected insects may be the result of breakdown of fat body protein by the pathogen *F. tribolii*. RABINDRA *et. al.* (1981) reported that in *F. tribolii*-infected fat bodies of larvae of *T. castaneum*, the albuminoid granules disappeared as the disease progressed. Further, actively multiplying protozoans themselves could have contributed to the increased uric acid content of the diseased larvae since urea, a product of uric acid metabolism is excreted as a waste product by protozoa (KITCHING, 1967).

The sodium content in diseased insects was higher than in healthy larvae but

TABLE 1. Total carbohydrates in healthy and *Farinocystis tribolii* infested larvae of *Tribolium castaneum.*

Days after inoculation	Total carbohydrate (mg/g wet weight) Mean* (N = 3) ± S E		% increase (+) or decrease (—) over healthy
	Healthy	Diseased	
2	7.93 ± 0.01	8.72 ± 0.24	+ 10.1
4	9.28 ± 0.05	5.76 ± 0.14	— 37.9
6	10.12 ± 0.48	7.12 ± 0.12	— 29.6
8	10.32 ± 0.08	5.76 ± 0.14	— 44.2
10	10.24 ± 0.05	6.08 ± 0.05	— 40.6

* Differences between the means of healthy and diseased significant (P = 0.05) by least significant difference on all days.

TABLE 2. Glycogen content in healthy and *Farinocystis tribolii* infected larvae of *Tribolium castaneum.*

Days after inoculation	Glycogen (mg/g wet weight) Mean* (N = 3) ± S E		% decrease over healthy
	Healthy	Diseased	
2	2.00 ± 0.05	1.93 ± 0.04	3.5
4	2.84 ± 0.04	1.75 ± 0.01	38.4
6	3.03 ± 0.05	1.33 ± 0.02	56.1
8	3.24 ± 0.06	1.98 ± 0.02	51.2
10	3.99 ± 0.03	1.03 ± 0.04	74.2

* Differences between the means of healthy and diseased significant (P = 0.05) on all days except the second day by least significant differences.

TABLE 3. Total nitrogen content or healthy and *Farinocystis tribolii*-infected larvae of *Tribolium castaneum.*

Days after inoculation	Total nitrogen (% dry weight) Mean* (N = 3) ± S E		% increase (+) or decrease (−) over healthy
	Healthy	Diseased	
2	6.77 ± 0.05	6.67 ± 0.06	− 1.5
4	6.39 ± 0.06	7.79 ± 0.04	+ 21.9
6	6.77 ± 0.11	7.75 ± 0.19	+ 14.5
8	6.77 ± 0.05	7.70 ± 0.02	+ 13.7
10	6.39 ± 0.04	7.19 ± 0.10	+ 12.5

* Differences between the means of healthy and diseased significant (P = 0.05) by least significant difference on all days except the second day.

TABLE 4. Uric acid content in healthy and *Farinocystis tribolii*-infected larvae of *Tribolium castaneum*.

Days after inoculation	Uric acid (% dry weight) Mean* (N = 3) ± S E		% increase (+) or decrease (−) over healthy
	Healthy	Diseased	
2	0.203 ± 0.017	0.187 ± 0.012	— 7.9
4	0.200 ± 0.010	0.400 ± 0.012	+ 100.0
6	0.213 ± 0.012	0.307 ± 0.011	+ 44.1
8	0.193 ± 0.014	0.280 ± 0.013	+ 45.1
10	0.260 ± 0.011	0.377 ± 0.012	+ 45.0

* Differences between the means of healthy and diseased significant (P = 0.05) by least significant difference on all days.

TABLE 5. Sodium content in healthy and *Farinocystis tribolii*-infected larvae of *Tribolium castaneum*.

Days after inoculation	Sodium (% dry weight) Mean* (N = 3) ± S E		% increase over healthy
	Healthy	Diseased	
2	0.057 ± 0.002	0.075 ± 0.003	31.6
4	0.058 ± 0.001	0.078 ± 0.002	34.5
6	0.060 ± 0.002	0.083 ± 0.002	38.3
8	0.072 ± 0.003	0.087 ± 0.001	20.8
10	0.094 ± 0.001	0.094 ± 0.002	38.2

* Differences between the means not significant.

TABLE 6. Potassium content in healthy and *Farinocystis tribolii*-infected larvae of *Tribolium castaneum*.

Days after inoculation	Potassium (% dry weight) Mean* (N = 3) ± S E		% increase (+) or decrease (−) over healthy
	Healthy	Diseased	
2	0.94 ± 0.38	0.81 ± 0.33	— 13.8
4	0.73 ± 0.30	0.88 ± 0.36	+ 20.6
6	0.75 ± 0.31	0.92 ± 0.37	+ 22.7
8	0.70 ± 0.29	0.89 ± 0.36	+ 27.1
10	0.56 ± 0.23	0.80 ± 0.33	+ 42.9

* Differences between the means of healthy and diseased significant on all days (P = 0.05) by least significant difference.

TABLE 7. Phosphorus content in healthy and *Farinocystis tribolii*-infected larvae of *Trtbolium castaneum*.

Days after inoculation	Phosphorus (% dry weight) Mean* (N = 3) ± S E		% increase over healthy
	Healthy	Diseased	
2	0.65 ± 0.003	0.66 ± 0.002	1.5
4	0.59 ± 0.004	0.72 ± 0.003	22.0
6	0.62 ± 0.002	0.87 ± 0.003	40.3
8	0.58 ± 0 004	0.85 ± 0.002	46.6
10	0.50 ± 0.002	0.88 ± 0.001	76 0

* Differences between the means of healthy and diseased significant (P = 0.05) by least significant difference on all days except the second day.

the differences during the different days were not significant (Table 5). Regarding potassium (Table 6) and phosphorus (Table 7), the levels were significantly higher in diseased larvae from fourth day of infection. The increased levels of sodium and potassium may be associated with the increased level of uric acid, as MULLINS & COCHRAN (1974) found that in the American cockroach, deposition of uric acid was associated with increases in K^+ and in some cases Na^+. The increased phosphorus levels may either be due to the increased levels of DNA (RABINDRA, 1979) or due to the breakdown of phospholipids by the pathogens.

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BIOEFFICACY OF FOUR SYNTHETIC PYRETHROIDS AGAINST *PLUSIA ORICHALCEA* FABR. FEEDING ON SUNFLOWFR

S. C. GOEL & VINEET KUMAR

PG-Department of Zoology, Sanatan Dharm College, Muzaffarnagar, India 251 001

(Received 14 November 1987)

Deltmethrin, cypermethrin, fenvalerate and permethrin were evaluated to establish LD_{50} for the third instar caterpillar of *P. orichalcea*. The LC_{50} estimated were 0.000095, 0.00027, 0.00095, 0.001172% and LD_{50} 0.03496, 0.07878, 0.1196 and 0.15019 μg / gm of body weight for these insecticides. Deltamethrin proved to be most toxic. The relative persistent toxicity index was taken as a parameter for final comparison of the bioefficacy on newly hatched caterpillars. The LT_{50} recorded was maximum for deltamethrin (12.32 days) than cypermethrin (10.38 days), fenvalerate (6.38 days) and permethrin (5.80 days).

(Keywords: bioefficacy, synthetic pyretaroids, deltamethrin, cypermethrin, fenvalerate, mealy bug parasitoid, *Anagyrus dactylopi)*

INTRODUCTION

The semilooper *Plusia orichalcea* Fabr. is considered to be a very important defoliator of sunflower crop in North-west India. As heavy defoliation will affect the ultimate yield of sunflower crop, it is essential that the crop is protected from the severe damage caussd by this insect species. The present paper deals with the evaluation of the synthetic pyrethroids viz., deltamethrin, cypermethrin, fenvalerate and permethrin which are known to be highly effective against lepidopterous pests on various crops.

MATERIALS AND METHOD

Appropriate quantities of technical grade material of each insecticide was dissolved in acetone to make a stock solution and further dilutions were made by acetone to prepare different working concentration. One ml solution of each insecticide was taken in petridish to form a uniform film. The larvae were allowed for 30 minutes in contact with the insecticidal film and mortality counted after 24 hours. LD_{50} was also assessed with the treatment of one microlitre dose of each insecticide on the thoracic terga. Results for LC_{50} and LD_{50} were determined by probit analysis (FINNEY, 1952).

The experiment for persistent toxicity was conducted on sunflower. Ten neonate larvae were released on freshly picked leaves from the insecticide treated plots in laboratory until the mortality due to insecticide gradually declined practically to negligible level. The persistent toxicity was also studied on the PT and LT_{50} values. The PT was determined by criterion developed by SAINI (1959) LT_{50} elaborated after PRADHAN (1967), and calculated by probit analysis after FINNEY (1952).

OBSERVATIONS

A disease free stock culture of *P. orichalcea* developed in laboratory on sunflower leaves was tested for the susceptibility of deltamethrin, cypermethrin, fenvalerate and permethrin by dry film (LC_{50}) and topical application

TABLE 1. Average persistent toxicities of synthetic pyrethroids against first instar larvae of *Plusia orichalcea* Frbr. together with their P T values and relative efficacy.

Treatment	Conc. (%)	P	T	PT	RPT	ORE
Deltamethrin	0.001	19	55.68	1057.92	1.67	1
Cypermethrin	0.01	17	58.08	987.36	1.56	2
Fenvalerate	0.01	15	46.05	690.75	1.09	3
Permethrin	0.05	13	48.69	632.97	1.00	4

P = Period; T = Average persistent toxicity; PT = Index of persistent toxicity; RPT = Relative persistent toxicity; ORE = Order of relative efficacy based on PT values.

techniques (LD_{50}). For third instar caterpillars, the LC_{50} and LD_{50} for deltamethrin was 0.000095% and 0.03496μg/g of body weight respectively. Similarly LC_{50} for cypermethrin, fenvalerate, permethrin was 0.00027, 0.00095, 0.00117% respectively whereas LD_{50} was 0.07878, 0.11960, 0.15018μg/g of body weight respectively.

The persistence of synthetic pyrethroids as indicated by LT_{50} showed that deltamethrin was most persistent (with LT_{50} of 12.32 days), followed by cypermethrin with LT_{50} of 10.38 days. Permethrin was least effective among the synthetic pyrethroids having LT_{50} of 5.80 days only. In order of relative residual toxicity fenvalerate was placed third (with LT_{50} of 6.38 days).

Comparing the residual toxicity for these pyrethroids it showed these were 2.212, 1 79, 1.10 times more persistent than permethrin. Deltamethrin gave 100% mortality upto 3 days and cypermethrin for one day only. Deltamethrin gave larval mortality upto 19 days, cypermethrin 17 days and fenvalerate upto 15 days, whereas permethrin gave larval mortality upto 13 days only. Based on persistent toxicity, the order of toxicity for these pyrethroids was deltamethrin > cypermethrin > fenvalerate > permethrin (Table 1).

DISCUSSION

The LC_{50} and LD_{50} for these pyrethroids against third instar larvae of *P. orichalcea* showed that deltamethrin was most toxic. Among the four synthetic pyrethroids permethrin was least toxic as evident from highest LD_{50}. The LD_{50} of deltamethrin for *Heliothis virescens* was 0.044 μg/g body weight (SPARK *et al.*, 1982).

Based on persistent toxicity of synthetic pyrethroids, it was evident that deltamethrin 0 001% showed the highest PT values followed by cypermethrin 0.01%, fenvalerate 0.01% and permethrin 0.05%. The respective PT values for these insecticides were 1057.92, 987.36, 690.75 and 632.97. Deltamethrin persisted for a longer period upto 19 days followed by cypermethrin 17 days and fenvalerate 15 days. Permethrin persisted for a shorter period giving larval mortality upto 13 days only. Similar trend of persistence of these synthetie pyrethroids was reported by SHARMA *et al.* (1986) against *Heliothis armigera* Hb. on gram.

The order of relative efficacy based on LT_{50} values of these insecticides were deltamethrin 0.001%, cypermethrin 0.01%, fenvalerate 0.01% and permethrin 0.05%. Taking LT_{50} of permethrin as unit, deltamethrin, cypermethrin and fenvalerate were 2.12, 1.79 and 1.10 times more toxic than permethrin. According to NIMBALKAR & AJRI (1981), the LT_{50} values for cypermethrin (0.01%), deltamethrin (0.0003%), fenvalerate (0.015%) and permethrin (0.01%), were 20.58, 20.05, 17.18 and 13.75 days for *Earias fabia* Fb. on okra crop. SAGAR (1985) while considering the comparing efficacy of ten insecticides on *Heliothis armigera* evaluated that deltamethrin was the most effective insecticide, and next in order of effectiveness were cypermethrin and fenvalerate. PRASAD *et al.* (1986) observed that the deltamethrin is more effective than the fenvalerate, with 0.0015% and 0.01% relative efficacy respectively on *Spodoptera litura* Fabr. LT_{50} values for deltamethrin (10 g a i / ha) and cypermethrin (40 g a i/ ha) were 12.56 and 9.64 days for *Heliothis armigera* Hb. on gram were observed by SHARMA *et al.* (1986). The present study, therefore, revealed that deltamethrin was the most toxic among all synthetic pyrethroids against *P. orichalcea* and this in conformity with the previous experiments carried out against other lepidopterous pests.

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BIOLOGY OF THE GRAPE MEALYBUG PARASITOID, *ANAGYRUS DACTYLOPII* (HOW) (ENCYRTIDAE : HYMENOPTERA)

M. MANI & T. S. THONTADARYA[1]

Division of Entomology and Nematology, Indian Institute of Horticultural Research, Bangalore, India 560 089

(Received 2 October 1987)

Anagyrus dactylopii (How.) was the principal parasitoid of the grape mealybug, *Maconellicoccus hirsutus* (Green) in southern parts of India. Its life cycle was studied in the laboratory at 25–28°C and 66-70 per cent relative humidity. Duration of the egg, grub and pupa of *A. dactylopii* was 1.30, 6.20 and 6.30 days, respectively when reared on *M. hirsutus*. Males lived for 14.75 days and female parasitoid lived for 22.00 days. An average of 39.30 progeny was produced by this parasitoid.

(Keywords: biology, mealybug, *Anagyrus dactylopii*, *Maconellicoccus hirsutus)*

INTRODUCTION

The encyrtid, *Anagyrus dactylopii* (How.) is an endolarval indigenous parasitoid of *Maconellicoccus hirsutus* (Green). In grape gardens, it was found parasitising *M. hirsutus* to an extent of 70 per cent around Bangalore (MANJUNATH, 1985; MANI *et al.*, 1987). Information on *A. dactylopii* is scanty, and the present investigation was undertaken to study the life cycle, longevity and fecundity of this encyrtid.

MATERIALS AND METHOD

Culture of the parasitoid was maintained on *M. hirsutus* in the laboratory as outlined by CHANDLER *et al.* (1980) for *Anagyrus pseudococci* (Girault). Lifecycle was studied by releasing 200 female parasitoids in a wooden cage having pumpkin harbouring 500 mealybugs. After four hours of exposure, all the parasitoids were removed. Twenty mealybugs were dissected daily to determine the incubation, grub and pupal period of *A. dactylopii*.

Freshly emerged 50 male and 50 female parasitoids were released together in a glass vial (15 × 2.5cm). They were fed with 50 per cent honey solution. Mortality of each sex was recorded daily until all the adults died; the longevity was computed.

To study the fecundity, freshly emerged male and female parsitoids were held together in a round bottom plastic jar, measuring 10 × 8 cm for 24 h to facilitate mating. They were fed with 50 per cent honey during this period. Each pair consisting of a female and male was confined in a round bottom plastic cage (20 × 15 cm), having potato sprouts infested with 25–30 mealybugs of 15 days old. The fecundity study was carried out studying 10 such pairs. Each pair was transferred daily to a fresh cage having potato sprouts with mealybugs. This procedure was continued till all the females died. The exposed mealybugs were reared until all the adult parasitoids emerged. The life cycle studies were carried out in the laboratory at 25—28°C and 66—70 per cent relative humidity.

RESULTS AND DISCUSSION

Lifecycle : Egg :

The egg which was deposited within the mealybug, was white and oval with a

Contribution No. 103/87 of the Indian Institute of Horticultural Research, Bangalore 560089.

[1] No. 256. Ist 'N' Block, Rajaji Nagar, Bangalore 560 010.

slender yellowish stalk. The newly deposited egg measured 0.21 × 0.19 mm, and the stalk measured 0.14 mm. These measurements are comparable with observations made on *A. pseudococci* by ROSEN & ROSSLER (1966). Incubation period varied from 1 to 2 days with a mean of 1.30 days (Table 1). Egg development took 1—4 days for different species of *Anagyrus* as reported by MOURSI (1948a), RIHERD (1950) and AVIDOV *et al.* (1967).

Larva:

The young larva remained in close contact with the egg shell. The full grown grub was 13-segmented and measured 1.54 m (length) × 0.77 mm (width). The parasitic grub took 6 to 7 days with a mean of 6.20 days to complete the development. This is comparable with that of *A. pseudococci* which took 4 to 5 days to complete the grub development (DOMENICHINI, 1951; AVIDOV *et al.*, 1967). The parasitised mealybug was found alive for 4 to 5 days, but its movement ceased from 5th day after oviposition. Subsequently the integument of the parasitised mealybug became hardened due to formtion of parasitoid pupa inside.

Pupa

The mealybug with parasitoid pupa inside is mummy. Mummified mealybug was cylindrical measuring 2.10 × 1.05mm. Pupal development was completed in 6 to 8 days with a mean of 6.30 days. Similar pupal period was recorded for other species of *Anagyrus* (RIHERD, 1950; AVIDOV *et al.*, 1967).

Adult

Sexual dimorphism in the form of size, colour and antenna between males and females was observed in adults of *A. dactylopii*.

The female parasioid was yellowish brown in colour legs white, abdomen slightly longer than thorax and ovipositor concealed, antennae elongated and clubbed; entire scape, proximal pedicel and first funiucle black, larger than male. It measured 1.89 mm long and 0.70 mm wide. It took 14.20 (14 to 16) days to complete the development from egg to adult.

TABLE 1. Biology of the parasitoid, *A. dactylopii* on grape mealybug *M. hirsutus*.

Particulars	(Duration days (Mean ± S D)
Egg period	1.30 ± 0.48
Larval period	6.20 ± 0.74
Pupul period	6.30 ± 0.63
Total development	
— Male	13.20 ± 0.45
— Female	14.20 ± 0.71
— Mean of male & female	13.80 ± 0.69
Longevity	
— Male	14.75 ± 3.29
— Female	22.00 ± 2.42

S D = Standard deviation.

The male was black in colour; smaller than females; legs and wings white; abdomen shorter than thorax; antenna filiform with white scape and black dorso-laterally funicular segments asymmetrical, black with numerous whorls of hairs. Male measured 1.12 mm × 0.49 mm. Developmental period was 13.20 (13 to 15) days.

Males emerged slightly earlier than the females but the difference was insignificant. A mean development of 18 days for *A. pseudococci*, *Anagyrus kamali* Moursi and *Anagyrus antoninae* Timberlake was reported earlier by DOMENICHIN (1951), MOURSI (1948 a) and RIHERD (1950).

Longevity

Females lived longer than males. Longevity of the male parasitoid was 10 to 18 days with a mean of 14.75 days. Females lived for 18 to 26 days with a mean of 22 days. The longevity of *A. dactylopii* was very short when compared to *A. kamali* and *Anagyrus aegyptiacus* Moursi which lived for several months at 25°C (MOURSI, 1948a; b).

Fecundity

Mating and oviposition took place immediately after emergence. During the first five days, the oviposition was high. A mean of 39.30 eggs per female was observed in the oviposition period of 18 days. Similar findings in case of *A. pseudococci* were documented by AVIDOV *et al.* (1967).

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EVALUATION OF SOME SYNTHETIC PYRETHROIDS AND CARBARYL FOR THE CONTROL OF BOLLWORMS AND THEIR EFFECT ON YIELD PARAMETERS OF COTTON[1]

J. P. SHARMA[2]

Division of Entomology, Indian Agricultural Research Institute, New Delhi, India 110 012

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Three synthetic pyrethroids namely, cypermethrin and fenvalerate each at 100g a i / ha and deltamethrin at 17.5g a i / ha, *vis-a-vis* carbaryl at 1250g a i /ha were evaluated, by initiating the spraying at two stages of crop growth (i e , at 50% square formation and at 50% boll formation), for their effects on the incidence of bollworms *viz*., *Earias* spp and *Pectinophora gossypiella* Saund. and yield parameters of 'Bikaneri Nerma cotton *(Gossypium hirsutum* Linn). All the three pyrethroids proved almost equally effective and superior to carbaryl in controlling bollworms and increasing the yield of seed cotton. Initiation of spraying at 50 per cent square formation gave better results.

(*Key words:* cypermethrin, fenvalerate, deltamethrin, bollworm incidence, *Erias* spp., *Pectinophora gossypiella*)

INTRODUCTION

Bollworms, namely, spotted bollworms, *Earias vittella* Fab. and *Earias insulana* Boisd., pink bollworm, *Pectinophora gossypiella* (Saund) are the major pests of cotton (*Gossypium* spp.) in northern India. They had defied almost all the insecticides used for their control till the discovery of synthetic pyrethroids which, on the basis of trials conducted in India and abroad, have shown great potential for combating these pests (RUSCOE, 1980; GUPTA & AGARWAL, 1983; GUPTA *et al.*, 1984). In the present studies also, three synthetic pyrethroids *vis-a-vis* carbaryl have been evaluated against cotton bollworms so as to find out the most effective insecticide and the appropriate time to initiate spraying.

MATERIALS AND METHODS

'Bikaneri Nerma' cotton *Gossypium hirsutum* Linn.) was sown in 60 m² plots (spacing: 75 × 30 cm) at Northern India Textile Research Association (NITRA) farm, Ghaziabad (U P) on 5.6.1980. Four insecticides namely, cypermethrin (100g a i / ha), deltamethrin (17.5g a i / ha), fenvalerate (100 g a i / ha) and carbaryl (1250g a i / ha) were used. Control (untreated) was also kept as check plot. Insecticidal spraying was initiated at two stages of crop growth: (i) at 50 per cent square formation stage i e., with setting squares in at least 50 per cent plants (D1 treatments) and (ii) at 50 per cent boll formation (D2 treatments). The spray interval was 10 days for the first four sprays followed by 21 days interval till the spraying in all the treatments. In total 6 and 5 sprays were given for D1 and D2 treatments, respectively. All the treatments were replicated thrice in Randomised Block Design. One cover spray of dimethoate at 800g a i/ha was given in the initial stage of the crop.

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[1] A part of approved Ph. D. thesis submitted to P G School, I A R I, New Delhi—12.

[2] Present address : Asst. Entomologist, Doctor Yashwant Singh Parmar University of Horticulture & Foresty, Nauni, Solan (H P)—173230.

The observations were recorded from randomly selected sample of ten tagged plants in each plot. No plant was tagged on the border rows. The damage of bollworms was assessed at various intervals after spraying (Tables 1 to 3). Observations were recorded on the percentage incidence of bollworms in squares and bolls, population of spotted and pink bollworms, boll bearing per plant, boll weight, boll maturity i. e., boll opening, plant height and yield of raw cotton. The percentage incidence of bollworms was subjected to angular transformations (Arc sin $\sqrt{\text{percentage}}$) for statistical analysis.

RESULTS AND DISCUSSION

Early initiation of spraying at D1 stage of crop was found very effective in protecting the squares (Table 1). In the first observation on 9.8.1980, taken after four days of spray initiation, only 2.2 to 2.6 per cent incidence of bollworms was recorded in D1 treatments, whereas it was 5.2 to 11.1 per cent in the untreated plots (i. e., control and D2 treatments). In the remaining three observations on squares (14.8.1980 to 29.8.1980) most of the synthetic pyrethroid treatments manifested significantly less damage than carbaryl or control. Repeated spraying had further reduced the incidence in both D1 and D2 treatments of pyrethroids and it did not exceed 2 per cent in the second fortnight of August. This shows that all the three pyrethroids were equally effective and better than carbaryl in protecting the squares from bollworms either by preventing the moths to lay eggs (repellent effect) and/or by their ovicidal/larvicidal action.

In bolls, all the insecticidal treatments suppressed the population of bollworms significantly over control. The

TABLE 1. Effect of synthetic pyrethroids *vis-a-vis* incidence of bollworms in squares.

Treatment	Dose (g) a i / ha	Percentage squares damaged			
		Dates of observations			
		9.8.1980	14.8.1980	24.8.1980	29.8.1980
Fenvalerate D1	100	2.2 (8.5)a	4.6 (12.4)ab	1.0 (5.8)a	1.2 (6.4)ab
Fenvalarate D2	100	5.7 (13.8)bc	6.5 (14 8)b	1.7 (7.4)ab	2.0 (8.1)bc
Cypermethrin D1	100	2.3 (8.7)a	4.8 (12.7)ab	1.1 (6.1)a	0.9 (5.4)a
Cypermethrin D2	100	5.2 (13.2)abc	6.0 (14.2)ab	1.7 (7.4)ab	1.8 (7.6)abcd
Deltamethrin D1	17.5	2.6 (9.3)ab	2.6 (9.2)a	1.2 (6.3)a	1.3 (6.5)ab
Deltamethrin D2	17.5	7.8 (16.2)cd	5.0 (12.9)ab	1.7 (7.6)ab	1.6 (7.3)abc
Carbaryl D1	1250	7.0 (15.4)cd	7.0 (15.4)b	2.2 (8.5)bc	2.8 (9.7)cd
Carbaryl D2	1250	11.1 (19.5)d	7.6 (16.1)b	3.4 (10.6)c	3.0 (10.0)d
Control	—	10 5 (18.9)d	6.4 (14.6)b	6.3 (14.6)d	5.2 (13.2)e
Mean (Insecticides)		5.5 (13.1)	5.5 (13.5)	1.8 (7.5)	1.8 (7.6)
SEM ±		1.6	1.7	0.7	0.9
C D at 5%		4.7	5.1	2.1	2.5

Note : Figures followed by the same alphabet (s) in a given column do not differ significantly. Figures in parentheses are the mean of transformed values.

TABLE 2. Incidence of bollworms in bolls (% loculi damaged)

Treatment	Dose (g) a i /ha	Green bolls				Open bolls (SBW + PBW	
		SBW		PBW		at first picking	at second picking
		30.9.80	21.10.80	30.9.80	21.10.80		
Fenvalerate D1	100	0.5 (4.1)a	0.5 (4.1)a	0.5 (4.1)a	2.0 (8.1)b	2.4 (8.9)a	1.4 (6.8)a
Fenvalerate D2	100	1.1 (6.0)a	0.5 (4.1)a	1.1 (5.9)ab	1.0 (5.8)ab	3.5 (10.8)ab	2.0 (8.2)a
Cypermethrin D1	100	0.5 (4.1)a	0.5 (4.1)a	0.5 (4.1)a	0.5 (4.1)a	2.1 (8.3)a	1.8 (7.7)a
Cypermethrin D2	100	0.5 (4.1)a	0.5 (4.1)a	1.5 (7.1)ab	1.4 (6.9)ab	3.2 (10.2)ab	2.0 (8.2)a
Deltamethrin D1	17.5	1.1 (6.0)a	0.5 (4.1)a	0.8 (5.2)ab	0.8 (5.2)ab	2.5 (9.0)a	1.5 (6.9)a
Deltamethrin D2	17.5	1.5 (7.1)a	0.5 (4.1)a	2.5 (9.0)ab	1.3 (6.5)ab	3.6 (10.9)ab	1.7 (7.5)a
Carbaryl D1	1250	1.1 (6.0)a	0.5 (4.1)a	4.1 (11.7)b	10.9 (19.3)c	5.8 (13.9)bc	4.3 (12.0)b
Carbaryl D2	1250	1.9 (7.9)a	1.1 (5.9)a	2.2 (8.6)ab	9.0 (17.5)c	7.0 (15.3)c	4.3 (12.0)b
Control	—	7.3 (15.7)b	2.8 (9.6)b	12.0 (21.1)c	19.8 (26.4)b	15.0 (22.8)d	11.9 (20.2)c
Mean (Insecticides)		1.0 (5.7)	0.6 (4.3)	1.7 (7.0)	3.4 (9.2)	3.8 (10.9)	2.4 (8.7)
SEM ±		1.7	0.6	2.1	1.3	1.2	1.3
C D at 6%		5.1	1.9	6.4	3.8	3.7	3.7

Note : Figures followed by the same alphabet(s) in a given column do not differ significantly. Figures in parentheses are mean of transformed values. D1 = Spray initiated at 5% square formation stage; D2 = Spray initiated at 5% boll formation stage. SBW = Spotted bollworm, PBW = Pink bollworm.

initial observation, on 30 9.80, have shown comparatively lower damage of bollworms in D1 than D2 treatments in all the insecticides but the differences were non significant both for spotted bollworm (SBW) and pink bollworm (PBW) (Table 2). Similarly in the subsequent observations i.e., on 21.10.1980 in green bolls and at first and second pickings in open bolls, all the pyrethroid treatments were at par with each other but showed significantly lower damage than carbaryl only for PBW in green bolls and both for SBW and PBW in open bolls at second picking. Untreated plots, however, showed significantly higher damage than the treated ones. Therefore, initiation of spraying at D1 or D2 stage did not show any significant difference so far as their impact on locule damage in bolls was concerned. This was because early initiation of spraying had already shown its effect in protecting squares and when the bolls were formed, D2 and D1 treatments received the same amount of sprays.

In general, all the insecticidal treatments reduced the larval population of PBW and SBW significantly over control (Table 3). Among insecticides, all the treatments of pyrethroids were at par in controlling SBW population. But for PBW population, among pyrethroids, cypermethrin D2 on 14.9.1980, deltamethrin D2 on 30.9.1980 and fenvalerate D1 on 21.10.1980 showed the maximum number of larvae per 100 bolls. The remaining pyrethroid treatments were at par with each other. However, in general, all the pyrethroids were statistically superior to carbaryl. Although D1 treatments of all insecticides showed comparatively fewer larvae of bollworms than their D2 treatments, the differences were not appreciable. The last observation on 20.1.1980 was made on carry over population of bollworms. It revealed no significant differences among insecticidal treatments (Table 3). However, untreated plants showed significantly higher larval population of bollworms than the treated ones. This showed that early initiation of spraying had no effect on the carry over population of bollworms. Evidently, the last application of insecticides seems to have had a direct bearing on the carry over of bollworms.

The data on the maturity of bolls (i. e., boll opening), number of bolls per plant, boll weight, plant height and yield of seed cotton have been presented in Table 4. Early initiation of spraying was very effective in early maturity of bolls. In all insecticides, except carbaryl, D1 treatments gave significantly higher percentage of opened bolls than their respective D2 treatments. Among pyrethroids, D1 treatments of fenvalerate and cypermethrin were at par with deltamethrin D1 but gave significantly higher number of opened bolls than rest of the treatments at first picking. Oviously, effective protection of earlier formed bolls has resulted in their early maturity. Pyrethroids, being more effective in protecting the reproductives from pest attack, have given early maturity of bolls than carbaryl. Secondly, growth stimulating effect of pyrethroids might have resulted in early opening of bolls as reported earlier by WEAVER and co-workers (1979). All the insecticides showed statistically similar boll bearing per plant irrespective of their spray initiation at any stage of the crop. However, among insecticides, D1 treatments of fenvalerate and cypermethrin manifested significantly higher number of bolls per plant than the control. The number of bolls per plant ranged between 31.5 (carbaryl D1) to 37 6 (fenvalerate D1) in treated plants, whereas it was only 27.2 in the control. The differential efficacy

TABLE 3. Effect of synthetic pyrethroids on the larval population of bollworm in green bolls.

		Number of larvae per 100 bolls							
		Spotted bollworm				Pink bollworm			
		dates of observation				dates of observation			
		14.9.1980	30.9.1980	21.10.1980	21.11.1980*	14.9.1980	30.9.1980	21.10.1980	20.11.1980*
Fenvalerate D1	100	1.6 (7.2)a	0.5 (4.1)a	0.5 (4.1)a	0.8 (5.3)a	2.5 (9.0)a	0.5 (4.1)a	7.0 (15.3)b	2.3 (8.6)a
Fenvalerate D2	100	1.6 (7.2)a	1.6 (7.2)a	0.5 (4.1)a	1.4 (6.7)a	8.7 (17.1)ab	2.5 (9.0)ab	2.5 (9.0)ab	2 5 (9.1)a
Cypermethrin D1	100	0.5 (4.1)a	0.5 (4.1)a	0.5 (4.1)a	1.8 (7.7)ab	3.3 (10.4)a	0.5 (4.1)a	0.5 (4.1)a	2.5 (9.0)a
Cypermethrin D2	100	3.3 (10.4)ab	0.5 (4.1)a	0.5 (4.1)a	1.8 (7.8)ab	12.1 (20.3)b	4.4 (12.2)ab	4.4 (12.2)ab	2.7 (9.4)a
Deltamethrin D1	17.5	0.5 (4.1)a	0.6 (4.4)a	0.5 (4.1)a	1 9 (8.0)ab	3.3 (10.4)a	1.6 (7.2)ab	1.6 (7.2)ab	2 0 (8.1)a
Deltamethrin D2	17.5	1.6 (7.2)a	1.6 (7.2)a	0.5 (4.1)a	1.8 (7.8)ab	4.4 (12.2)ab	7.0 (15.4)ab	3.3 (10.4)ab	2.2 (8.5)a
Carbaryl D1	1250	1.6 (7.2)a	1.6 (7.2)a	0.5 (4.1)a	3.1 (10.1)ab	7.0 (15.3)ab	12.1 (20.3)b	28.8 (32.5)c	4 3 (12.0)a
Carbaryl D2	1250	4.4 (12.2)ab	3.3 (10.4)a	1.6 (7.2)a	5 0 (12.9)b	8.7 (17.1)ab	7.0 (15.4)ab	30.5 (33.5)c	4 6 (12.4)a
Control	–	10.5 (18.9)b	12.1 (20.3)b	8.7 (17.1)b	11.9 (20.2)c	27.0 (31.3)c	34.9 (35.8)c	89.3 (70.9)b	18.6 (25.5)b
Mean (Insecticides)		1.9 (7.5)	1.3 (6.1)	0.6 (4.5)	2.2 (8.3)	6.3 (14.0)	4.5 (11.0)	9.8 (15.5)	2.9 (9 6)
S E M±		1.4	2.1	1.2	2.0	3 0	3.0	3.5	3.4
C D at 5%		8.7	6.4	3.6	5.9	8.9	15.1	10.6	10.2

Note : Figures followed by the same alphabet (s) in a given column do not differ significantaly. Figures in parentheses are mean of transformed values. * Carry over population (larvae / 100 loculi) in left over bolls after the last picking.

TABLE 4. Effect of insecticides on yield and its related parameters.

Treatment	Dose (g) ai /ha	boll opening (%) at first picking	No. of bolls / plant at 1st picking (green+ open)	boll weight (g)	plant height (cm)	yield (q/ha)	per cent increases in yield over control
Fenvalerate D1	100	45.5 (42.4)a	37.6a	3.0a	117.3	25.40ab	108 0
Fenvalerate D2	100	27.3 (31.5)c	33.3ab	2.9a	104.1	24.50abc	100.8
Cypermethrin D1	1 0	50.5 (45.3)a	34.9ab	3.0a	116.4	24.70abc	102.3
Cypermethrin D2	100	32.1 (34 5)bc	31.8ab	3.0a	116.2	23.80abc	95.1
Deltamethrin D1	17.5	43.6 (41.3)ab	35.6a	3.1a	119.5	25.90a	111.9
Deltamethrin D2	17,5	27.6 (31.7)c	32 9ab	2.8a	113.9	23.48abc	91.6
Carbaryl D1	1250	28.7 (32.4)c	31.5ab	2.6a	109.7	20.50c	68.3
Carbaryl D2	1250	31.4 (34.1)c	32.7ab	2.7a	112.9	20.90bc	71.3
Control	—	28.4 (32.2)c	27.2b	2.0b	102.4	12.20d	—
Mean (Insecticides)		35.8 (36 7)	33.8	2.9	113.8	23.60	—
S EM ±	—	2.3	2.6	0.2	7.0	1.7	—
C D at 5%	—	6.9	7.9	0.5	NS	4.8	—

Figures in parentheses are the mean of transformed values. Figures followed by the same alphabet (s) in a given column do not differ significanty.

of these chemicals has resulted in variation in boll bearing. The more effective treatments have resulted in arresting the shedding of reproductives because the attack of bollworms was minimised which, otherwise, is directly related with shedding of reproductives particularly in the early stage of the crop (AGARWAL & KATIYAR, 1979) and consequently giving lower number of bolls as observed in control plants. Secondly, growth stimulating effect of pyrethroids might have resulted in vigorous plants with more number of reproductives (KATHANE & BHAMBURKAR, 1978). For plant height, the differences between treated and control plants were non significant. However, in case of average boll weight, all the insecticidal treatments showed their superiority over control by giving significantly higher weight per boll (2.6 to 3.1g) than control (2.0g). It was due to pest free conditions, created by the use of insecticides, which has resulted in vigorous plants with increased boll weight. In this case also, though the pyrethroid treatments resulted in comparatively higher weight per boll (2 8 to 3.1g) than carbaryl, yet statistically all the insecticides were on par with each other.

Early initiation of spraying was comparatively more effective in increasing the yield as compared to the delayed application of insecticides at D2 stage of the crop in each of the pyrethroid treatments. However, this was not true with

carbaryl. Statistically, only deltamethrin D1 gave significantly higher yield (25.85q / ha) than both the treatments of carbaryl. The minimum yield (12.20q / ha) was recorded in control. The per cent increase in yield over control ranged between 91.64 to 111.88 in pyrethroids and 68.28 to 71.31 in carbaryl treatments.

Thus, keeping in view, the above mentioned observations, it can be concluded that spraying should be initiated at 50 per cent square formation stage. Synthetic pyrethroids should be preferred over carbaryl because the latter was found inferior to all the three pyrethroids irrespective of their spray initiation at D1 or D2 stage of the crop. Among pyrethroids, the differences were, in general non significant.

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CONTROL OF BREEDING OF *ORYCTES RHINOCEROS* L. IN MANURE BY TREATING THE BOTTOM SOIL OF THE MANURE PITS WITH INSECTICIDES

A. VISALAKSHI, K. SANTHAKUMARI & N. MOHANDAS

College of Agriculture, Vellayani, Trivandrum, India 695 522

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The bioassay of different insecticides to full-grown grubs of rhinoceros beetle of coconut, *Oryctes rhinoceros* L. showed HCH as most highly toxic followed in the descending order by aldrin, heptachlor, DDT, chlordane and carbofuran. The field experiments showed that the treatment of soils beneath the manure pits with aldrin at 0.12 and HCH at 0.2 kg ai / m^3 caused more than 90 per cent kill of the grubs. This can hence be a new approach for the control of rhinoceros beetle population in the field

(Key words: coconut, crhinoceros beetle, aldrin, HCH)

The rhinoceros beetle *Oryctes rhinoceros* L. (Scarabaeidae : Dynastinae) is a serious pest of coconut palm. For reducing the beetle population in the field the recommended method is treatment of the manure in pits with insecticides (ANON, 1984) to kill the grubs. Since cowdung is being stored in pits for long periods repeated treatment may be necessary for effective kill of the grubs. The grown-up grubs have the habit of migrating to the soil below the manure pits for pupation. So there exists a possibility of killing these migrating grubs if the soil is treated with persistent insecticides. This proposition was tested in a series of experiments results of which are presented in this paper.

MATERIALS AND METHODS

Relative toxicity of six commonly used soil insecticides (Table 1) to the full-grown grubs of the beetle was assessed by bioassay. The insecticides were applied at five sequential doses to the soil and thoroughly mixed. HCH and DDT were applied as wettable powder formulation, carbofuran as granules and other insecticides as emulsion concentrates. The treated soil was filled in pots of 30 × 35 cm, to a height of 15 cm and fresh cowdung put above it to a height of 20 cm. Ten full grown grubs of rhinoceros beetles were introduced into each pot.

Pots with soil treated with water alone served as control. Each treatment was replicated thrice. The count of the dead and surviving grubs/pupae was taken at the end of 6 weeks. The data were subjected to probit analysis (FINNEY, 1952).

Based on the relative efficacy of the six insecticides aldrin and HCH were chosen for further studies. A multi-locational field experiment was conducted in areas with different types of soil, viz. Chirayinkil (sandy soil), Kodappanakkunnu (laterite soil) and Vellayani (red soil). The insecticides were used at the rate of 0.12 and 0.06 kg ai/m^3 of soil. Pits (75 × 75 × 75 cm) were taken in coconut gardens. Soil at the bottom of the pit was treated with the required quantities of the insecticide emulsion to a depth of 15 cm. Over 100 kg of fresh cowdung was put. Two days later ten full grown grubs were introduced into each pit. The pits were covered with wire mesh to prevent emerging adults going

out of the pits. The pits were watered periodically to prevent drying of the cowdung. Each treatment was replicated ten times. Ten pits in which bottom soil was treated with water alone formed the control. Mortality counts were taken four months after the release of the grubs.

In a second field experiment efficacy of higher doses of HCH and lower doses of aldrin was assessed. The experiment was laid out as in the first field experiment with treatments detailed in Tabe 3.

RESULTS AND DISCUSSION

Results of bioassay of the six insecticides tested (Table 1) showed that HCH was the most toxic and it was followed in the descending order of toxicity by aldrin, heptachlor, DDT, chlordane and carbofuran. The relative toxicity was in agreement with the findings reported earlier (ANON, 1969).

The results of the multilocatalional trial (Table 2) indicated that though both aldrin and HCH caused significant reduction in grub population compared to control at all the three locations, the mortality of the grubs caused by HCH was not satisfactory. Though the toxicity of HCH was three times than that of aldrin in the bioassay assessment, HCH at half the dose of aldrin applied in the field experiment was ineffective. In the bioassay studies HCH might have caused higher mortality through fumigant effect in the flower pots. In the second field experiment two lower doses of aldrin and two higher doses of HCH were evaluated.

The results presented in Table 3 show that at HCH applied at 0.2 kg ai / m^3 caused a mortality of 93.9 per cent which was significantly superior to all other treatments. HCH at 1 kg ai / m^3 came on par with aldrin at 0.05 and 0.075 kg ai / m^3.

TABL 1. Relative toxicity of different insecticides to full-grown grubs of *Oryctes rhinoceros* based on probit analysis.

Insecticide	Hetero-geneity	Regression equation	L C 50	Fiducial limits	relative toxicity
HCH	0.67	Y = 0.6774X + 4.0184	0.0099	.0066—.0141	1.00
DDT	0.75	Y = 0.95X + 1.34	0.0478	.03631—.06310	0.207
Carbofuran	1.57	Y = 1.33X + 3.11	0.0831	.0588—.01148	0.119
Heptachlor	5.66	Y = 0.93X + 3.55	0.0398	0245—.0645	0.249
Aldrin	1.30	Y = 1.3 X + 2.29	0.0318	.0143—.0505	0.311
Chlordane	1.62	Y = 1.34X + 1.14	0.0752	0.0519—0.1121	0.132

TABLE 2. Mortality of full grown rhinoceros beetle grubs 4 months after release, in manure pits at different location with the bottom soil of pits treated with insecticides.

Insecticide	% mortality of grubs at different locations		
	Chirayinkil	Kodappanakkunnu	Vellayani
Aldrin	100	99.9	99.6
(0.12 kg a i/m³)	(90.0)	(88.16)	(86.31)
HCH	9	6.7	31.7
(0.06 kg a i/m³)	(17.6)	(14.9)	(34.2)
	2	0.34	17.4
	(8.2)	(3.3)	(26.6)
C D at 5% level	8.92	9.59	5.41

Values in parantheses are transformed values.

TABLE 3. Mortality of full grown rhinoceros beetle grubs in manure pits with bottom soil treated with different insecticides.

Insecticide	Dose kg ai/m³	% mortality (mean values)
Aldrin	0.05	60.3 (50 99)
Aldrin	0.075	69.0 (56.15)
HCH	0.1	70.0 (56.92)
HCH	0.2	93.9 (75.69)
Control	—	8.8 (17.27)
C. D. at 0.05%	14.598	

Values in parantheses are transformed values.

The data in Tables 2 and 3 reveal treatments of bottom soil of manure pits with aldrin at 0.12 kg ai / m³ or HCH at 0.2 kg ai / m³ which gave more than 90 percent kill / of the grubs could be recommended for the control of the breeding of rhinoceros beetles in manure pits.

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REDESCRIPTION OF TWO ORIENTAL SPECIES OF GENUS *LACCOTREPHES* STAL (HETEROPTERA : NEPIDAE) WITH A KEY TO SOUTH INDIAN SPECIES

S. RAVISANKAR[1] & P. VENKATESAN

Department of Zoology, Loyola College, Madras, India 600 034

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Laccotrephes griseus (Guer.) and *L. ruber* (Linn.) are described and discussed with related species from India based on the sexual dimorphic and alpha characters. In addition, a key to the South Indian species of *Laccotrephes* Stal is provided.
(Key words: redescription, *Laccotrephes griseus, L. ruber,* key)

INTRODUCTION

Laccotrephes and *Montonepa* are the two genera belonging to the subfamily Nepinae and tribe Nepini (Menke and Stange, 1964) that occur in fresh water bodies of India. The taxonomy of *Laccotrephes* in the Oriental region is most confused and various names have been widely used in its biology (Singh, 1925; Mohamed and Murad, 1978; Tonapi, 1980). Available description of the oriental species of genus *Laccotrephes* are based on a few morphological characters (Distant, 1906, 1910; Rao, 1976). Neither the structure of genitalia of males and females described by Menke (1963) in species of other genera nor reliable alpha characters emphasized by Lansbury (1973) in Australian species have been attempted in oriental species. Hence redescription is made in *Laccotrephes griseus* and *Laccotrephes ruber* and a workable key for South Indian species is given.

Genus *Laccotrephes* Stal, 1865.

Type species: *Laccotrephes limosus* Stal, 1865 *Nepa* Guer. 1829–1838, Icongr. Regne Anim. Ins. 352 Two species *Nepa griseus* Guer; monobasic.

ADDITIONAL CHARACTERS

Right wing overlapping the left wing (dextral) in female; left wing overlapping the right wing (sinistral) in male; subgenital plate triangular in female and ovate in male; claw absent or fused in prothoracic leg; sixth tergal plate with a median longitudinal dark band in female and is absent in male.

Type species: *Laccotrephes griseus* (Guer.) (Figs. 1 & 2)

REDESCRIPTION

Nepa griseus Guer. Icongr. Renge Anim., 1829–38, Ins. p. 352. *Laccotrephes griseus* (Guer.) Montandon, 1897, Ann. Mus. Civ. Gen. XXXVII 377.

Laccotrephes maculatus Stal (part), 1868, Hem. Fabr. i, p. 135; Distant (part), 1906. Vol. III, p. 19, Hinton, 1962 Proc. Roy. Soc. Lond. (A) 37–65 : 69.

Laccotrephes griseus (Guer.)

Body: Long, elongated; respiratory siphon about two-thirds the body length to

[1] Department of Zoology, Kongunadu Arts & Science College, Coimbatore.

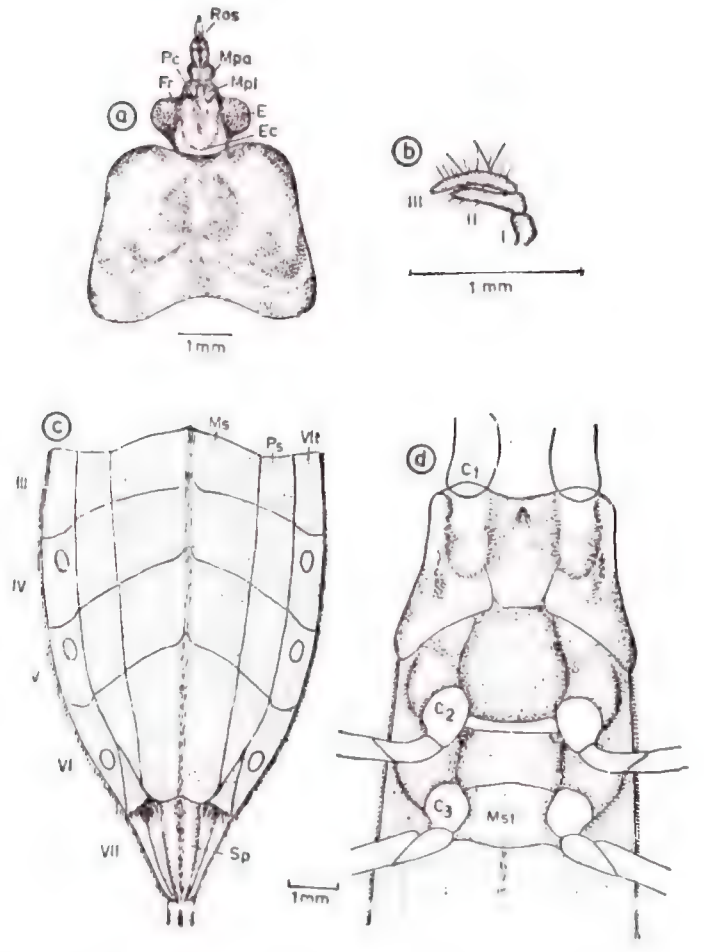

Fig. 1. *Laccotrephes griseus* (Guer.) a—Dorsal view of head and pronotum; b—Antenna; c—Ventral aspect of abdomen; d—Ventral view of thorax.

ABBREVIATIONS USED

Dorsal view of head and pronotum: E—Eye; Ec—Epiclypeus; Fr—Frons; Mpa—Maxillary plate; Mpl—Maxillary palp; Pc—post clypeus; Ros—Rostrum. Antenna: Segments I to III Ventral aspects of abdomen: Ms—Median sternite; Ps—Parasternite; Sp—Subgenital plate; Vlt—Ventral laterotergite; Segments III to VII. Ventral view of the thorax: C_1 to C_3—Coxa; base; Mst—Metasternum. Prothoracic leg: C—Coxa; F—Femur; T—Trochanter; Ta—Tarsus; Ti—Tibia. Mesothoracic leg: Cl—Claw. Hemelytra: A_1, A_2—Anals; C—Corium; Me—Membrane; R+M—Radial and Medial; Sc—Subcostal. Metathoracic wing: Cu—Cubital; M—Medial; Sc—Subcosta; R—Radial. Dorsal view of genitalia of male: Ac—Anal cone; Ad—Anterior diverticulum; Bbp—Basal bridge and basal plate; Gc—Genital capsule; Labp—Lateral arms of the basal plate; Mp—Median phallotheca; P—paramere; Slv—Sclerotized lever rod of vesica; Sp—Spatulate process; Vrc—Vesical rod complex. Lateral view of genitalia of female: Aa—Anal armature; Dp—Dorsal plate; Ds—Dorsal support; Lp—Lateral plate; O—Ovipositor; Pp—Palp like process. Ventral view of abdominal tip of female: Sp—subgenital plate.

the ratio of 2.5 : 1.8; body broad, flattened dorsally; dark brown when debris removed.

Head: Triangular, tapering anteriorly and fractionally narrower than anterior lobe of pronotum posteriorly to the ratio of 0.91 : 1.7; eyes small and oval, the interocular space more than the width of eye to the ratio of 0 9 : 0.8; rostrum stout and thick; vertex slightly raised; clypeus well differentiated; maxillary platelet not meeting in front of clypeus; antennae hidden; three segmented, median and apical segments elongate with stout hairs.

Pronotum: Distinct and almost rectangular; anterior margin less than posterior to the ratio of 3.72 : 4.65; anterior and posterior median angles moderately pitted with laterals smooth; transverse suture just above the posterior margin; inter-anterior lobe distance nearly equal to the inter-posterior lobe distance to the ratio of 2.00 : 1.95; median groove symmetrical from anterior to posteriorwards; prosternum with median longitudinal rounded ridge, more pronounced between prothoracic coxae and tapering pointed.

Scutellum: Triangluar, tapering posteriorly, with the maximum width and median length to the ratio of 0.4 : 0.5.

Leg: Prothoracic coxae larger than meso – and metathoracic coxae (1.53 : 0 91 : 0.98); mesothoracic coxae separated by more than twice the coxal width to the ratio of 2.05 : 0.95; metathoracic coxae by nearly twice the coxal width; prothoracic femora wider than meso– and metathoracic femora to the ratio of 1.50 : 0.70 : 0.85; metathoracic femora longer than meso– and prothoracic femera to the ratio of 2.06 : 1.56 : 1.90; claw absent or fused in prothoracic leg but two in meso– and metathoracic legs; prothoracic tibia and tarsus folding into deep depression of inner surface of femora; prothoracic femora with sulcus having fringes with a prominent tubercle on inner proximal margin; prothoracic tibia almost as long as sulcus.

Wings: Hemelytra parallel, thick and heavy, membrane thin with numerous reticulate veins; metathoracic wings membranous and hyaline; subcostal and radial + medial joined distally.

Abdomen: Flattened; 4th, 5th and 6th abdominal spiracles prominent; base of 6th abdominal sternite with small tuft of hairs covering the subgenital plate proximally.

Genitalia: Posterior abdominal segments telescoped to form anal and genital armatures; anal armature appeared to be formed from two plates, one dorsal and one ventral, each more strongly chitinized near the tip; genitalia triangular and armatured; two pairs of plate like structure forming slender ovipositors; dorsal plate with hairs at the apex; lateral plates broader proximally and narrower distally.

Male genitalia: Genital capsule anteriorly shallow, posteriorly broad; basal plate broad and hyaline; parameres symmetrical; slightly hooked and articulated with proximal region anal armature; bridge, basal plates, and lateral arms of the basal plates well sclerotized; spatulate process with fine setose hairs.

Sexual dimorphism:

Male: Body comparatively small; abdomen narrow; subgenital plate ovate; elytra sinistral (left wing overlapping the right); 6th tergal plate without median longitudinal dark band.

Female: Body comparatively large; abdomen broad; subgenital plate triangular; elytra dextral (right wing overlapping the left); 6th tergal plate with median black longitudinal dark band.

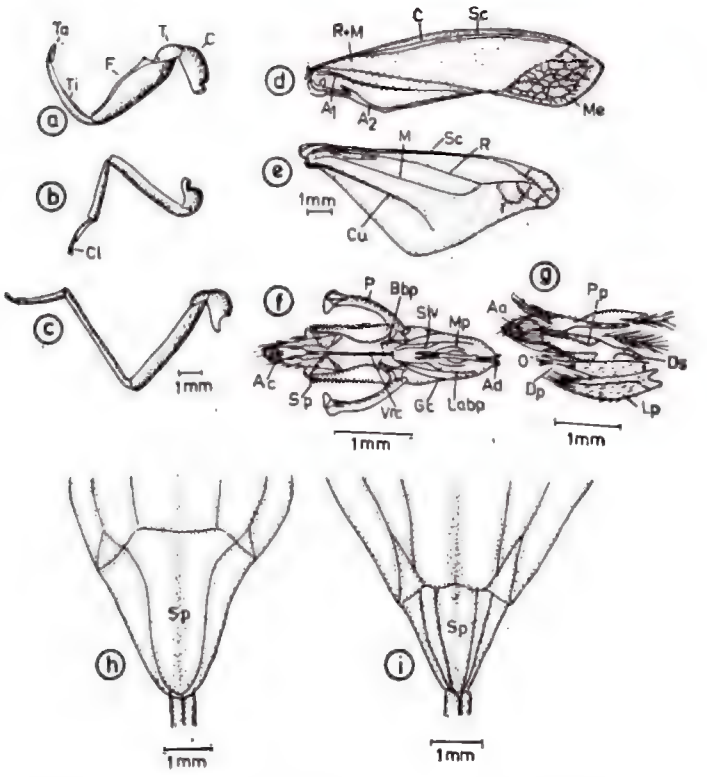

Fig. 2. *Laccotrephes griseus* (Guer.) a—Prothoracic leg; b—Mesothoracic leg; c—Metathoraic leg; d—Hemelytra; e—Metathroacic wing; f—Dorsal view of genitalia of male; g—Lateral view of abdominal tip of male; h—Ventral view abdominal tip of male; i—Ventral view of abdominal tip of female.

Type: Neotype-♀; Allotype ♂.

Date of collection: 25.xi.1982.

Location: Chetpet pond, Madras, India.

Deposited at: Loyola College Museum, Madras, India.

Measurements in millimeters–female (male in parenthesis):

Total body length 17.56 (15.25); greatest body width 5.42 (4 47); head length 1.70 (1.60); thorax length 6.46 (5.15); abdomen length 9.40 (8.50); head width 2.06 (1.82); rostrum length 1.24 (1.15); width of pronotum 3.92 (3.57); anterior margin of pronotum 3.72 (3.57); anterior margin of pronotum 4.65 (4.15); anteoculus 0.46 (0.51); interoculus 0.77 (0.72); prothoracic leg:- coxa 2.06 (1.53); trochanter 1.49 (1.11); femur 4.54 (3.81); tibia 3.51 (3.10); tarsus 0.77 (0.65); mesothoracic leg:- coxa 0.67 (0.81); trochanter 1.18 (0.95); femur 3.36 (3.12); tibia 2.42 (2.24); tarsus 1.13 (1.05); claw 0.56 (0.49); metathoracic leg:- coxa 1.03 (0.98); trochanter 1.34 (1.07); femur 4.91 (4.13); tibia 4.80 (4.17); tarsus 1.80 (1.63); claw 0.72 (0.56); respiratory siphon 13.44 (10.54).

Type species: *Laccotrephes ruber* (Linn.) (Figs. 3 & 4).

Redescription:

Nepa ruber Linn. Mus. Lud. Ulr. 1964, p. 165.

Laccotrephes ruber Linn. *(Nepa)* Distant, 1906, Fauna of British India, p. 18.

Laccotrephes ruber (Linn.)

Body: Large and broad; respiratory siphon slightly longer than the body length to the ratio of 0.7 : 0.2; body broad and flattened dorsally; convex ventrally; dark brown or light brown when debris removed.

Head: Triangular tapering anteriorly and fractionally narrower than anterior lobe of pronotum posteriorly to the ratio of 1.7 : 3.3; eyes large and oval; interocular space more than the width of the eye to the ratio of 3.0 : 2.0; vertex slightly raised; clypeus well differentiated; maxillary plates not meeting in front of clypeus; antennae hidden and three segmented, median and apical segment elongate with hairs on either sides; rostrum stout and thick.

Pronotum: Distinct and almost rectangular, narrow anteriorly and broad psoteriroly; anterior and posterior median

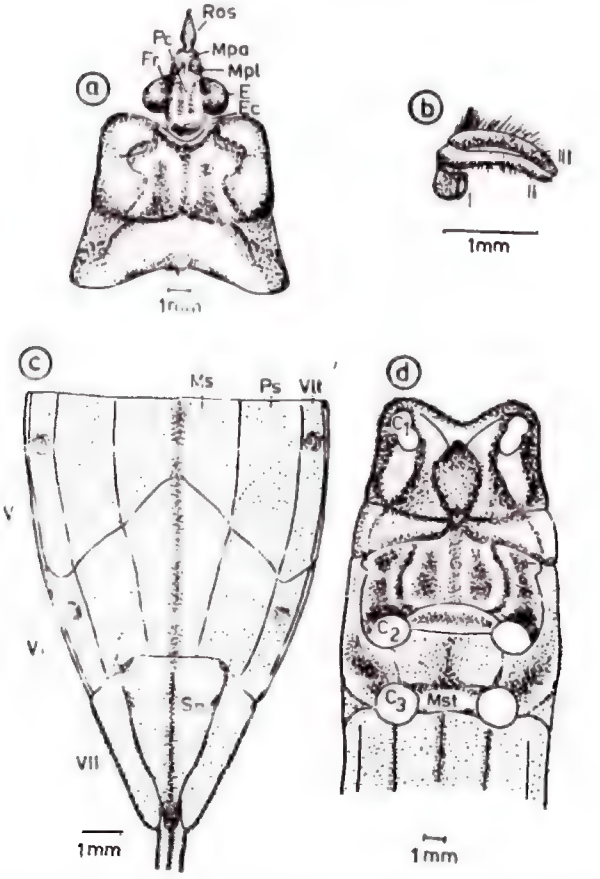

Fig. 3. *Laccotrephes ruber* (Linn.) For explanation of figures see Fig. 1.

angles moderately pitted with laterals smooth; transverse suture just above the posterior margin; inter-anterior lobe distance equal to the inter-posterior lobe distance; median groove symmetrical from anterior to posteriorwards; prosternum with median, longitudinal rounded ridge, more pronounced between prothoracic coxae and tapering pointed.

Scutellum: Triangular, tapering posteriorly, with flat median and raised laterally, with maximum median length to the ratio of 4.1 : 3.4.

Leg: Prothoracic coxae larger than meso- and metathoracic coxae to the ratio of 0.6 : 0.3 : 0.4; mesothoracic coxae separated by thrice the coxal width, prothoracic femora wider than meso- and metathoracic femorae to the ratio of 2.8 : 0.9 : 1.1; ratio of femoral length of pro-, meso- and metathoracic legs 10.1 : 7.5 : 10.3; tarsus one segmented; claw absent or fused in prothoracic leg but two in meso- and metathoracic legs; prothoracic femora with sulcus having fringes with a prominent tubercle on inner proximal margin; front tibia almost as long as sulcus; prothoracic tibia and tarsus folding into deep depression of inner surface of femora.

Wings: Hemelytra subparallel, thick and heavy, membrane thin with numerous reticulated veins; metathoracic wings membraneous and hyaline; subcostal, radial + medial united distally.

Abdomen: Yellowish or orange flattened and median line forming the ridge

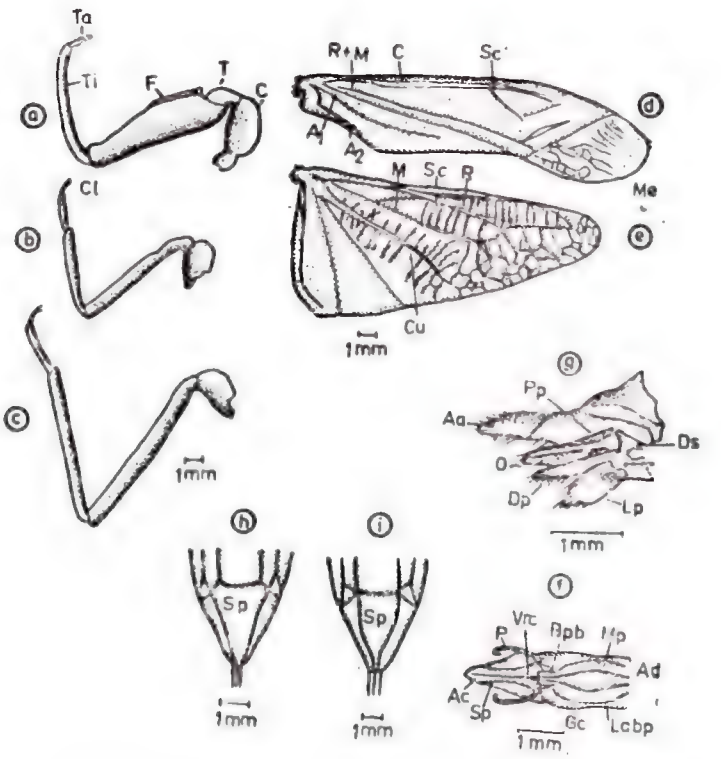

Fig. 4. *Laccotrephes ruber* (Linn.) For explanation of figures see Fig. 2.

longitudinally and ventrally; two longitudinal depressions running on either side of the median ridge; 4th, 5th and 6th abdominal spiracles prominent; subgenital plate of the 6th abdominal sternite smooth.

Genitalia: Posterior abdominal segments telescoped to form the anal and genital armature; anal armature appears to be formed from two plates, one dorsal and one ventral each more strongly chitinized near the tip; the genital armature rigid and stout; lateral plate leaf-like and bearing hairs at the tip; dorsal plate and pulp-like process equal.

Male genitalia: A pair of large outer plates bearing on each side a curved hooked paramere articulated with the proximal region of the anal armature; anal cone stout with a chitinous tip; basal plates overlapping at the midventral line.

Sexual dimorphism

Male: Body comparatively small; abdomen narrow; subgenital plate triangular: elytra sinistral (left wing overlapping the right); 6th tergal plate without median longitudinal dark band.

Female: Body comparatively large; abdomen broad; subgenital plate triangular; elytra dextral (right wing overlapping the left); 6th tergal plate with median longitudinal dark band.

Type: Neotype- ♀. Allotype ♂.

Date of collection: 5.ii.1983.

Location: Cheptet pond, Madras, India.

Deposited at: Loyola College Museum, Madras, India.

Measurements (in millimeters)—female (male in parenthesis):

Total body length 34.74 (31.46); greatest body width 9.54 (8.82); head length 3.28 (2.78); thorax length 12.06 (11.12); abdomen length 19.40 (17.56); head width 3.46 (3.20); rostrum length 2 10 (2.06); width of pronotum 7.82 (7.54); anterior margin of pronotum 6.62 (6.44); posterior margin of pronotum 9.04 (8.38); side angle length of pronotum 7.20 (7.06); anteoculus 1.48 (1.10); interoculus 1 48 (1.20); eye width 1.00 (1.00); prothoracic leg;- coxa 3.64 (3.54); trochanter 2.60 (2.30); femur 10.08 (9.06); tibia 8.04 (7.16); tarsus 1.78 (1.74); mesothoracic leg:- coxa 1.88 (1.86); trochanter 1.90 (1.88); femur 7.48 (7.10); tibia 5.50 (5.12); tarsus 2.28 (2.22); claw 1.18 (1.40); metathoracic leg:- coxa 2.44 (2.18); trochanter 2.16 (2.08); femur 10.32 (10.60); tibia 10.06 (8.92); tarsus 3.16 (2.98); claw 1.44 (1.34); respiratory siphon 35.44 (33.12).

Remarks

Laccotrephes griseus (Guer.) differs distinctly from its allied species *L. maculatus* Fabr. in possessing median longitudinal rounded ridge situated at the anterior region of prosternum, the abdominal appendages being proportionately larger and the prominent tubercle on the inner proximal margin of prothoracic femora being more obtusely rounded. However in size, colour and other external features, it evidently resembles *L. maculatus* Fabr. Further it differs from distantly related oriented species *L. ruber* (Linn.) in that the posterior pronotal angle and total body length are more in *L. ruber* than *L. griseus*. Also it varies markely from *L. elongatus* Montandon in having broad body, abdominal appendages proportionately large than the body length, the posterior pronotal angle smaller and interocular space less enlarged and almost equal in front to the greater diameter of the eye. Lansbury (1973) has reported that genus *Borborophye*s Stal is only likely to

be confused with *Laccotrephes* Stal in the oriental region. He has also mentioned that all species of *Laccotrephes* Stal have a prominent tubercle on inner proximal margin of prothoracic femur and the membrane is clearly separated from the hemelytra with distinct venation.

KEY TO SOUTH INDIAN SPECIES OF *LACCOTREPHES* STAL

1. Total body length more than 30 mm..... 2
   Total body length less than 30 mm 3
2. Body large, breadth between posterior pronotal angles less than 7 mm..... 4
3. Body small, breadth between posterior pronotal angles less than 7 mm..... 5
4. Total body length more than 36 mm ranging upto 44 mm; body broad, breadth between posterior pronotal angles 12 to 12.5 mm... .....*L. robustus* Stal
   Total body length less than 35 mm starting from 30 mm; body narrow, breadth betwen posterior pronotal angles 7 to 9 mm .....*L. ruber* (Linn.)
5. Anterior region of the prosternum with a strong acute tubercle..... 6
   Anterior region of the prosternum without a strong acute tubercle..... 7
6. Presence of prominent tubercle at the base of the inner margin of prothoracic femora being more obtusely rounded..... 8
7. Absence of prominent tubercle at the base of the inner margin prothoracic femora being less obtusely rounded..... .....*L. maculatus* Fabr.
8. Body elongate abdominal appendages proportionately shorter than the body length; posterior pronotal angle length 4.80 to 6.00 mm; interocular space much enlarged about twice broad in front than the greatest diameter of the eye...*L. elongatus* Montandon
   Body small and broad; abdominal appendages proportionately larger than the body length; posterior pronotal angle length 4 to 5 mm; interocular space less enlarged almost equal in front to the greatest diameter of the eye.....*L. griseus* (Guer.)

Acknowledgements: We are indebted to Rev. Fr. Principal, S. J. for the facilities extended to us and to Professor and Head, Dept. of Zoology, for encouragement. This work was supported by an I C M R Project.

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A NEW GENUS AND THREE NEW SPECIES OF TENUIPALPIDAE (ACARI) FROM TAMIL NADU

M. MOHANASUNDARAM

Department of Entomology, Tamil Nadu Agricultural University, Coimbatore, India 641 003

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The paper presents the description of a new genus Tenuipalpid mite, *Tenuilichus* gen. nov., with two new species under the genus, viz. *malvae* and *striatus Tenuipalpus bassiae* sp. nov., collected from Tamil Nadu

(Key words: Tenuipalpidae, *Tenuilichus*, *Tenuipalpus*)

In the course of survey and study of phytophagous mites of Tamil Nadu, three new species of Tenuipalpid mites were collected and studied. Among them, two new species did not fit into any of the known genus under Tenuipalpidae, hence a new genus is proposed to hold these species. All measurements given are μm.

Tenuilichus gen. nov.

This new genus resembles *Tenuipalpus* Donnadieu by the presence of the flagellate, penultimate pair of dorsolateral hysterosomal setae and palpus with three segments, but differentiated from it by the complete absence of the dorsocentral hysterosomal setae. None of the known species of *Tenuipalpus* has this feature. So also none of the known genera of Tenuipalpids, except *Terminalichus* Anwarullah and Khan (1973) has this character. The new genus is differentiated from *Terminalichus* by the flagellate, penultimate pair of dorsolateral hysterosomal setae. None of the five species of *Terminalichus* so far known has this character (Swaraj Ghai and Maninder Shenhmar, 1984).

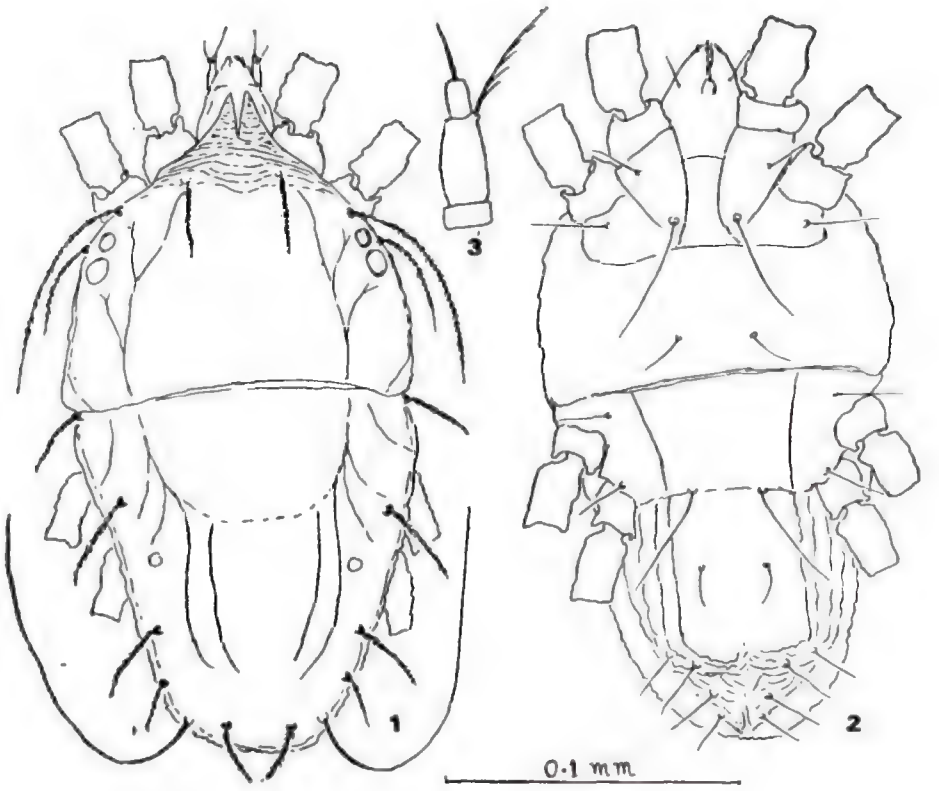
Dorsoventrally flattened mites, rostral shield cleft, palp with three segments, the distal two segments elongated with appendages in each. Propodosoma with 3 pairs of dorsal propodosomal setae and quite long, humeral setae present, dorsocentral hysterosomal and dorso–sublateral setae absent; five pairs of dorsolateral hysterosomal setae with the penultimate setae flagelliform. The ventral and genital plates fused to form a genitoventral plate. All usual ventral setation present.

Type species: **Tenuilichus malvae**, sp. nov.

Tenuilichus malvae, sp. nov. (Figs. 1–6)

Female: Flat, greenish, 250 long including rostrum; 120 wide; rostrum 35 long, reaching nearly the distal end of femur I; palpus 3 segmented; first segment 2 long; second segment 8 long; bulged with a hairy seta 11 long in the anterior half; third segment 3 long with 4 long spine at the tip.

Propodosoma with a few markings on the lateral sides, middle region clear; three pairs of dorsal propodosomal setae; DP I 38–40 long; DP II, 80–90 long; DP III 30 long; all setae are rough and spinose.



Figures 1—6. *Tenuilichus malvae* sp. nov. 1. Dorsal view of female. 2. Ventral view of female 3. Palp of female.

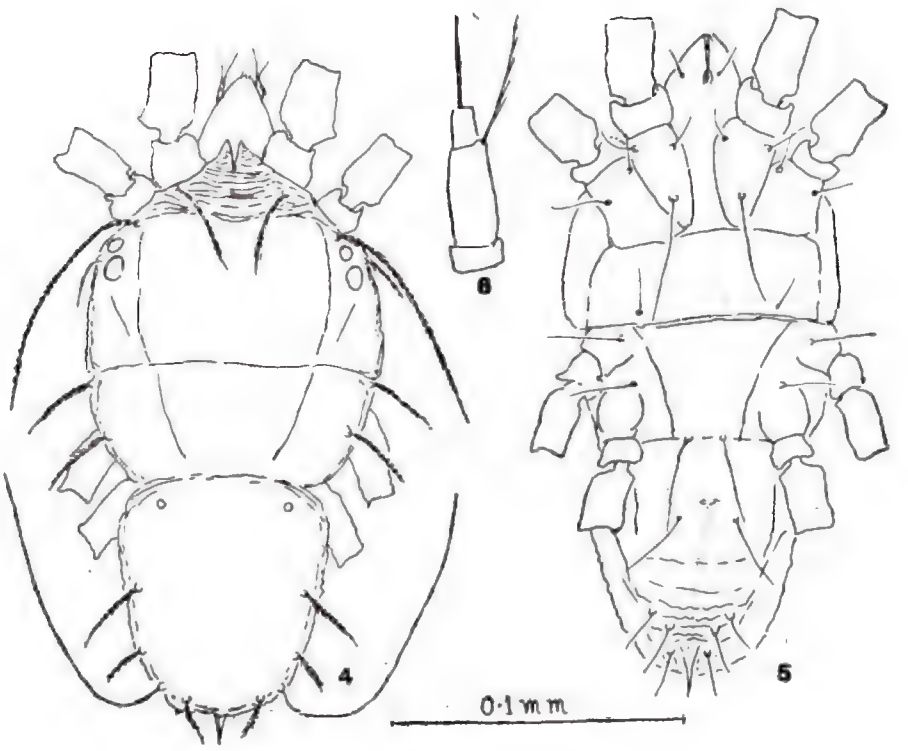
(Continued on P. 239)

Hysterosoma with lines and furrows on the lateral aspects, with the middle region fairly smooth. Dorsocentral setae absent; one pair of humerals 25 long; five pairs of dorsolaterals, DLH I 70–80 long; DLH II 20 long; DLH III 10 long; DLH IV flagellate, 115 long; DLH V 12 long; all setae on dorsum are rough and spinose except DLH VI which is smooth.

Venter smooth with a pair of anterior medioventral propodosomals, 60 long at the base of fore coxae, a pair of anterior medioventral metapodosomals above the humeral line, 12 long; one pair of posterior medioventral metapodosomals 45 long; one pair of pregenitals 10 long; two pairs of genital setae 12 and 10 long; two pairs of anal setae, inner pair 7 long and outer pair 8 long; all setae on venter simple.

Setae on legs I to IV; coxae, 2, 2, 1, 1; trochanter, 1, 1, 2, 1; femora 4, 4, 2, 2; genua 2, 2, 0, 0; tibiae, 4, 4, 3, 2; tarsi 4 (1), 4 (1), 4, 4, setae on dorsal and lateral aspects are lanceolate and serrate while those on ventral side, simple.

Male: Flat, greenish, 220 long, 195 wide; dorsal setation similar to female, ventral setation with three pairs of setae in the genitoanal region instead of 4 pairs as in the females.



(Continued from P. 238)

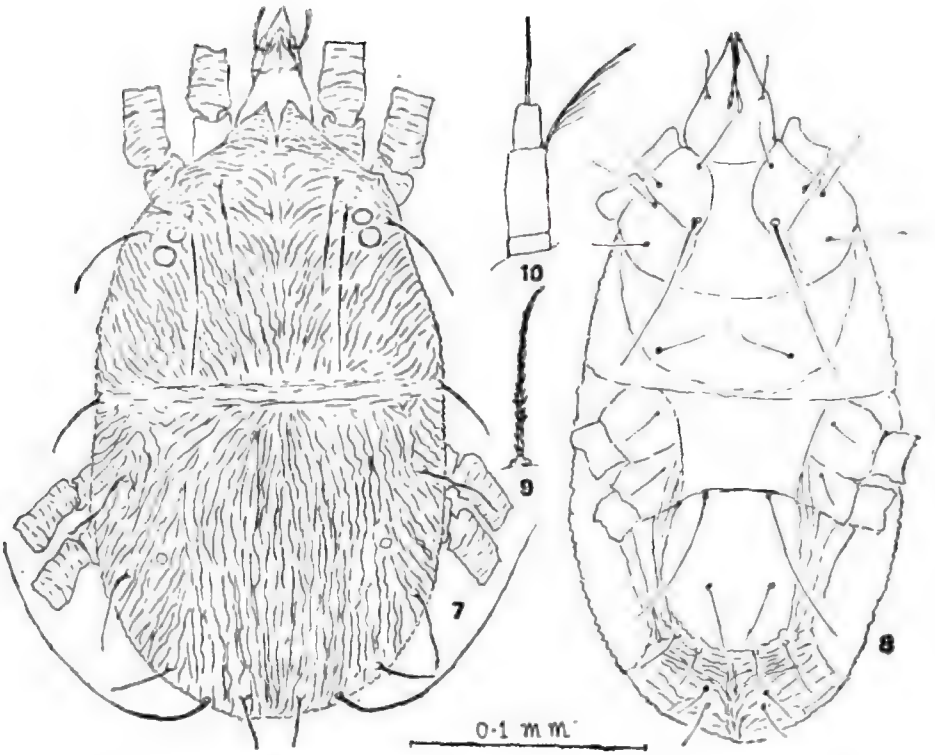
4. Dorsal view of male, 5. Ventral view of male, 6. Palp of male.

Types: A hototype ♀ marked on slide with 4 females and 3 males, and four paratype slides with four ♀♀ and two ♂♂ in each, INDIA; TAMIL NADU: Kallar 21.ix.1984 ex Malvaceous tree (Malvaceoxa), M. Mohanasundaram coll. (No. 107) (TNAU)

Tenuilichus striatus sp. nov. (Figs. 7–10)

Female: Flat, greenish, 300 long including gnathosoma, 150 wide; rostrum 55 long; reaching the middle of the fore tibia; palpus three segmented, basal segment 2 long; second segment 11 long with 15 long hairy seta at its tip; third segment 4 long with 8 long spine at its tip, gnathosoma with a pair of ventral setae. Rostral shield, propodosoma, and hysterosoma with a pattern of elongate wavy lines; propodosoma with three long, rough and spiny setae, DPI 50 long; DP II 70 long, DP III 38 long. Hysterosoma with the dorsocentral setae absent; one pair of humerals, 30 long; five pairs of dorsolateral hysterosomals, DLH I 45 long, DLH II 30 long, DLH III 15 long; DLH IV 130 long; flagellate; DLH V 15 long.

Venter, fairly smooth except for a few lines, with a pair of anterior medioventral propodosomals, 60 long, a pair of anterior medioventral metapodosomals/ above the humeral line, 25 long; one pair of posterior medioventral metapodosomals; 45 long; one pair of pregenital setae, 12 long, two pairs of genital setae and two pairs of anal setae; all setae on the venter, smooth and simple.



Figures 7—10 *Tenuilichus striatus* sp. nov. 7. Dorsal view of female 8. Ventral view of female 9. Dorsal seta, 10. Plap.

Setae on legs I to IV; coxae 2, 2, 1, 1; trochanter 0, 0, 2, 2; femora 4, 4, 2, 2; genua 2, 2, 0, 0; tibiae 4, 4, 3, 2; tarsi 5 (1), 5 (1) 5, 5, setae on dorsal and lateral aspects are rough and hairy while those on the ventral side, smooth, and simple.

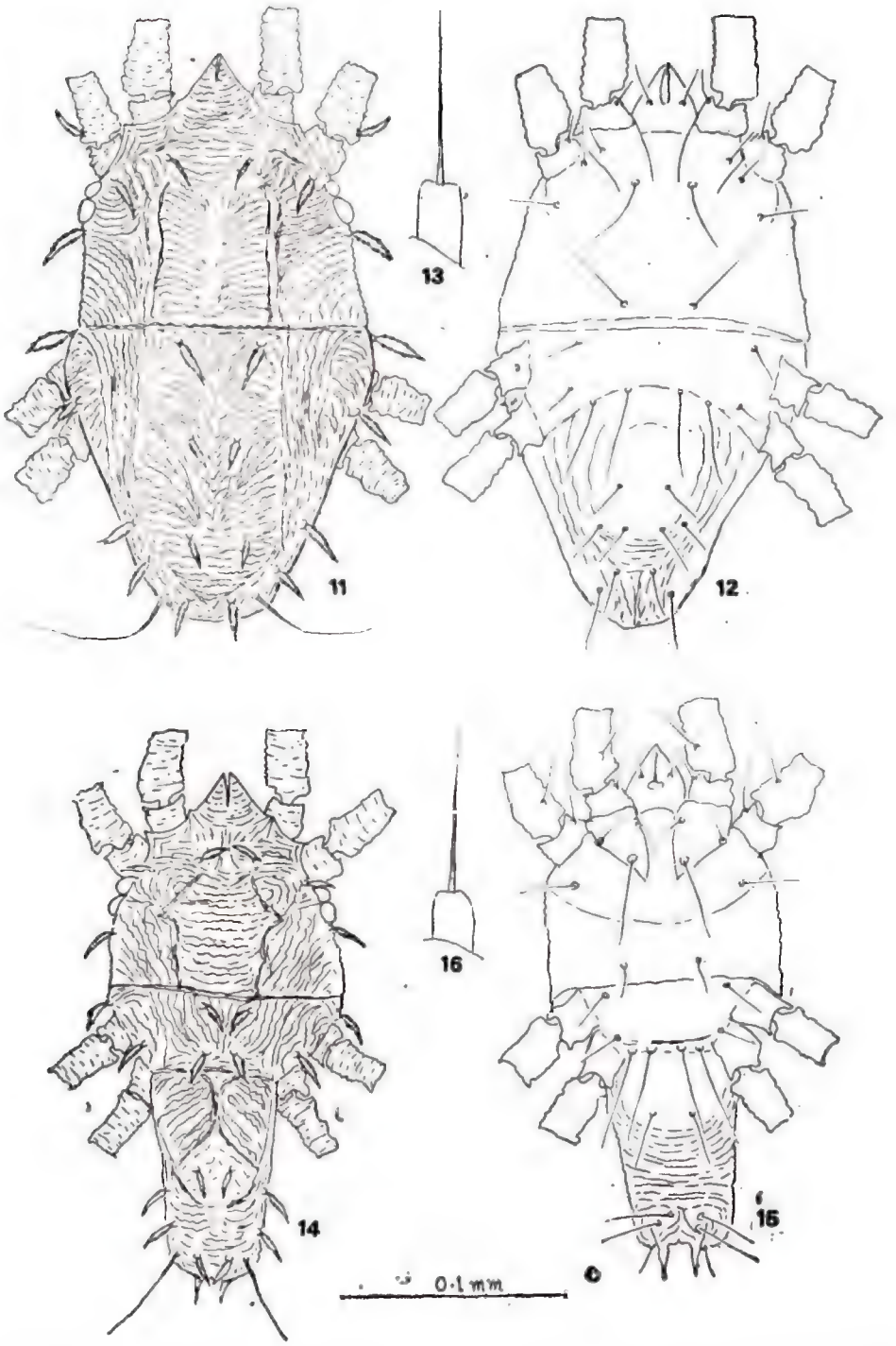
Male: *Not known.*

Types: A holotype ♀ marked on slide along with 3 ♀♀; and 3 paratype slides each with four females; INDIA: TAMIL NADU; Kallar, 21.ix.1984 ex unidentified tree M. Mohanasundaran coll. (No. 108) (TNAU)

Tenuipalpus bassiae sp. nov. (Fig. 11–16)

Female: Red in colour, 270 long including rostrum; 140 wide; rostrum completely covered by the triangular propodosomal shield, reaching nearly the middle of the femur I, palpus single segmented, 5 long, with a seta at the distal end, gnathosoma with a pair of simple setae on the ventral side.

Rostral shield narrowly bifurcate, as long as the rostrum with broad wing like expansion laterally covering the coxal bases of the first pair of legs; shield with corrugations and pattern of lines. Propodosoma with a pattern of wavy lines and channel like clear areas on either side of the mid line; three pairs of dorsal propodosomal setae, DP I, 7 long; DP II, 10 long and DP III, 12 long. Hysterosoma with a pattern of wavy lines; three pairs of dorsocentrals, DH I, 8 long; DH II, 6 long; DH III, 7 long, one pair of humerals, 10 long; five pairs of dorsolaterals, DLH



Figs. 11—16. *Tenuipalpus bassiae* sp. nov, 11. Dorsal view of female, 12. Ventral view of female, 13. Palp of female, 14. Dorsal view of male, 15. Ventral view of female, 16. Palp of male.

I, 7 long; DLH II, 7 long; DLH III, 8 long, DLH IV, 80 long flagellate; DLH V, 7 long; all setae on dorsum are lanceolate and serrate.

Venter with one pair of medioventral propodosomals 40 long, near the forecoxal base; a pair of anterior medioventral metapodosomals, 12 long; two pairs of posterior medioventral metapodosomals, the inner pair 45 long; the outer pair 25 long; a pair of medioventral setae 20 long on the ventral plate; two pairs of genital setae and two pairs of anal setae; all setae on venter simple.

Setae on legs I to IV: coxae, 1, 2, 1, 1; trochanter 1, 1, 1, 1; femora 4, 3, 2, 1; genu 3, 3, 1, 0; tibiae, 3, 3, 2, 2; tarsi, 5 (1), 5 (1), 4, 4; setae on the dorsal side of the legs lanceolate and serrate, while those on ventral side are simple.

Male: Flat, red in colour, 240 long, 100 wide, dorsal setation similar to female, ventral setation similar to female except for the reduction of one pair of anal setae. Dorsum with characteristic striation pattern, similar to that of female.

Types: A holotype ♀ on slide along with 5 females, 3 males and 1 nymph and 5 paratype slides each two with two males and four females; INDIA: TAMIL NADU: Coimbatore, ex *Bassia latifolia* Roxb. (Sapotaceae) 3.xi.1985, M. Mohanasundaram. Coll. (No. 124) TNAU.

Remarks: This species comes under the *T. caudatus* group in having 3 pairs of dorsocentral hysterosomal setae; 4 pairs of non flagellate and one pair of whip like caudolateral hysterosomal setae and with a single segmented palp. It resembles *T. keiensis* Meyer in the podosoma with 2 pairs of posterior medioventral setae but differentiated by the dorsal pattern, size of the serrate, lanceolate dorsal setae and the setal pattern on the legs (Meyer, 1979).

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HITHERTO UNKNOWN SEXUALS OF TWO APHID SPECIES (HOMOPTERA : APHIDIDAE) FROM WESTERN HIMALAYAS

S. SAHA & S. CHAKRABARTI[1]

Biosystematics Research Unit, Department of Zoology,
University of Kalyani, Kalyani, India 741 235

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Hitherto unknown sexuals viz. apterous oviparous female, apterous male and alate male of *Chaitophorus kapuri* Hille Ris Lambers and apterous oviparous female and alate male of *Nasonovia rostrata* David and Hameed are reported and described in this paper

(Key words: unknown sexuals, aphids, aphid predators, Western Himalayas)

Chaitophorus kapuri Hille Ris Lambers (1966) and *Nasonovia rostrata* David and Hameed (1974) were described from North west Himalayas. During recent surveys for aphids from Western Himalayas, hitherto unknown sexuals of these two species are collected. These morphs are described in this paper. All the materials described here are in the collection of Biosystematics Research Unit, Department of Zoology, University of Kalyani, Kalyani, India.

(Abbreviations used: b. d. III basal diameter of antennal segment III; h t 2 – second joint of hind tarsus; p. t. – processus terminalis; u. r. s. — ultimate rostral segment)

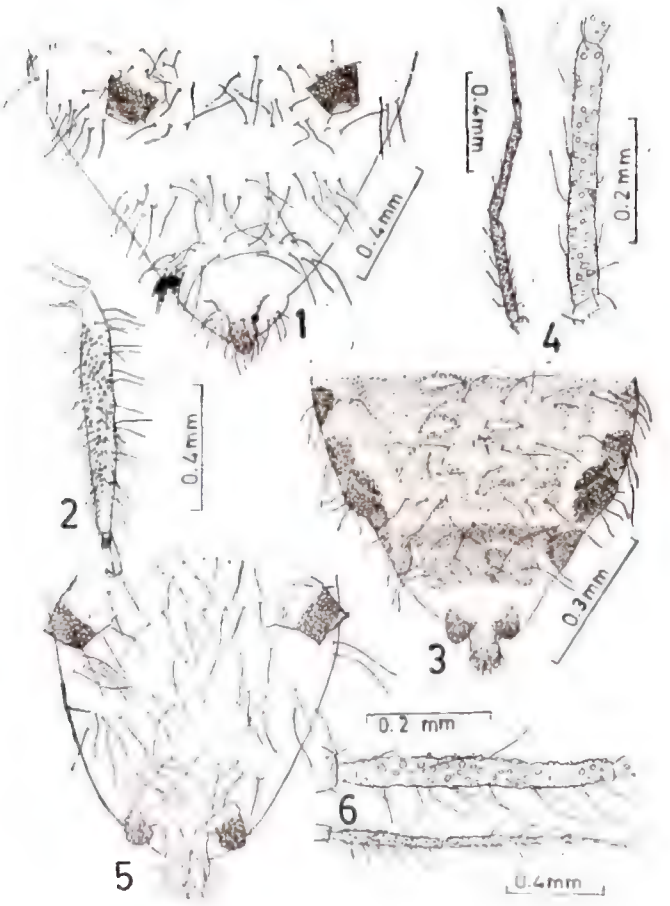
1. Chaitophorus kapuri Hille Ris Lambers

Chaitophorus kapuri Hille Ris Lambers, 1966. *Tijdschr. Ent.*, **109**, 197; Kumar, 1973. *Orient. Insects*, **7**, 11; Chakrabarti, 1977. *Orient. Insects*, **11**, 210; Ghosh, 1980. *Fauna of India*, Part I, 37; Agarwala and Ghosh, 1984. *Rec. Zool. Surv. India*, Occ. Paper No. 50, 24.

Hill Ris Lambers (1966) described the apterous and alate viviparous females of this species infesting *Populus ciliata* from Murree (*c* 2133 m), West Pakistan. Hitherto unknown apterous oviparous female, apterous male and alate male are described here.

Apterous oviparous female (Figs 1–2): Body 2.44–2.64 mm long and 1.29–1.32 mm wide. Head pale brown in colour, dorsal cephalic hairs with flagellate apices, longest one 5.36–5.50 times the b d.III. Antennae 0.45–0.49 times the body, segment I pale brown, rest of the flagellum pale, segments I and II with 8 and 4 hairs respectively, segment III smooth, with 14–17 hairs, rest of the flagellum gradually imbricated apicad; longest hair on antennal segment III 5.05–5.16 times the b d.III; p.t. 3.0–3.3 times the base and 0.81–0.90 times the antennal segment III, hairs on the flagellum with flagellate apices. u.r.s. 0.87–0.89 times the h.t. 2 and with 6–7 secondary hairs. Abdomen pale, anterior tergites with 35–40 hairs, longest one 5.0–5.2 times and shortest one 1.8–2.2 times the b.d. III respectively; tergite 7 with 24–30 hairs, longest one 7.2–8.0 times and tergite 8 with 18–22 hairs, the longest one 5.6–6.2 times the b.d.III respectively. Siphunculi pale, reticulated over the entire

[1]Correspondence : Dr. S. Chakrabarti.



Figs. 1—6. *Chaitophorus kapuri* Hille Ris Lambers 1—2. Apterous oviparous female: 1. Posterior portion of abdomen, 2 Hind tibia; 3—4. Apterous male: 3. Posterior portion of abdomen, 4. Antennal segments; 5—6. Alate male: 5. Posterior portion of abdomen, 6. Antennal segments.

surface, 0.03–0.04 times the body, 0.56–0.80 times the cauda, 0.65–0.89 times the h.t. 2 and 0.69–0.80 times the maximum width at base. Cauda constricted at middle, with 15–18 hairs. Legs pale, hind tibia with many small round pseudosensoria. Other characters as in apterous viviparous female.

Measurements of one specimen in mm: Body length 2.64, width 1.32; antenna 1.21, antennal joints III : IV : V : VI 0.33: 0.18 : 0.16 : (0.09 + 0.27); u. r. s. 0.12; h.t. 2 0.13; siphunculus 0.09; cauda 0.16.

Apterous male (Figs. 3–4): Body dark 1.3–1.69 mm long. Head slightly rugose with 12–15 cephalic hairs having acute or flagellate apices, longest one 4.0–4.65 times the b.d. III. Antennae 0.79–0.97 times the body, segment I brown, with 7–10 hairs, segment II pale, with 4 hairs, basal 0.8 portion of segment III pale, rest of the flagellum brown, segment III with

11–16 hairs, longest one 2.2–2.3 times the b.d. III, segments IV and V with 4–10 and 3–6 hairs respectively; segment III with 17–34, IV with 18–24 and V with 4–10 secondary rhinaria respectively. u.r.s. with 4 secondary hairs. Anterior abdominal tergites with 12–17 hairs, longest one 2 0–3.4 times the b.d. III; tergites 7 and 8 with 7–12 hairs. Siphunculi 0.71–1.1 times the cauda, 0.58–0.77 times the h.t. 2 and 1.0–1.1 times the maximum width at base. Cauda with 7 hairs. Legs pale. Other characters as in alate male.

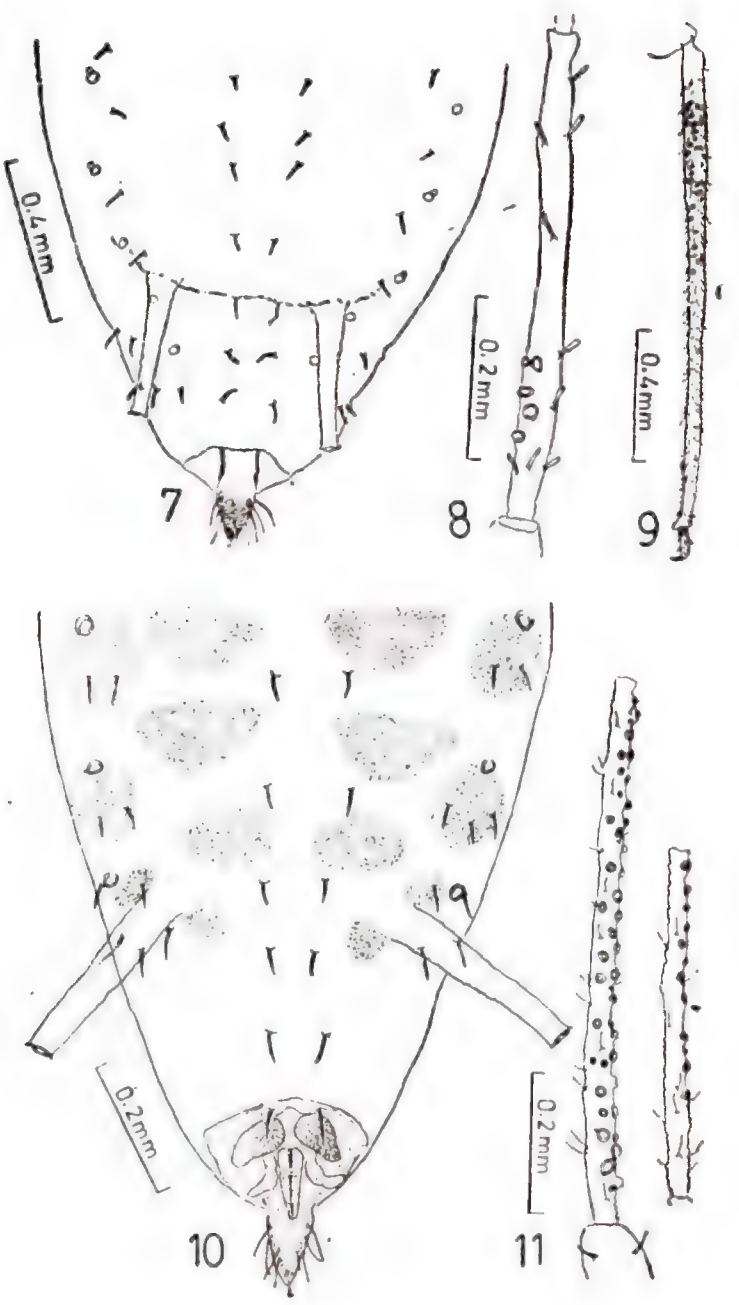
Measurements of one specimen in mm: Body length 1.41, width 0.66; antenna 1.37, antennal joints III : IV : V : VI 0.43 : 0.24 : 0.15 : (0.10 + 0.32); u.r.s. 0.07; h.t. 2,0.12; siphunculus 0.07; cauda 0.08.

Alate male (Figs. 5–6) : Body pale to pale brown, 1 83–2.17 mm long and 0.58–0.67 mm wide. Head pale brown, dorsum smooth, with about 16 hairs, longest one 5.3–6.35 times the b.d.III. Antennal segments I and II smooth and concolorous with head, each bearing 5 hairs, segment III with 18–19, IV with 7–9 and V with 6–7 hairs respectively, longest hair on segment III 4.5–5.6 times the b.d.III, segment III with 35–51, IV with 28–29 and V with 8–13 small, round secondary rhinaria distributed over the entire length of the respective segments; u.r.s. with 6 secondary hairs. Abdomen pale to pale brown, discontinuous pale sclerotic patches present spinally, pleurally and marginally on tergites 1–6, tergites 7 and 8 with two separate distinct continuous patches; longest hair on anterior abdominal tergites 4.5–5.6 times the b d.III; tergites 7 and 8 with 10–16 hairs, longest one 4.8–5.3 times the mentioned diameter. Siphunculi pale brown. Cauda with 8–9 hairs. Wings pale, media twice branched, veins distinct but very much faint at the points of origin and not touching pterostigma. Other characters as in alate viviparous female.

Measurements of one specimen in mm: Body length 2.17, width 0.67; antenna 1.49, antennal joints III : IV : V : VI 0.49 : 0.26 0.20 : (0.09+0.29); u.r.s. 0.12; h.t.2, 0.12; siphunculus 0.09; cauda 0.10.

Material studied: 85 apterous viviparous females and 37 nymphs, INDIA, UTTAR PRADESH, Sayanachatti (*c* 1770 m), 20 x.1981, 11 apterous oviparous females, 1 alate male and 8 nymphs, Bhuinder (*c* 2439 m), 24.x.1981, coll. S. Raha; 4 apterous viviparous females, 3 apterous oviparous females and 2 nymphs, Ghangaria (*c* 3770 m), 25.x.1981, coll. S. Chakrabarti, 5 apterous viviparous females, 1 apterous male, 1 alate male and 6 nymphs, Ghangaria (*c* 3770 m), 25.x.1981, coll. A. K. Mandal; 56 apterous viviparous females, 1 apterous male and 9 nymphs, Joshimath (*c* 1950 m), 26 x.1981, coll. S. Raha; 10 apterous viviparous females, 1 apterous male and 1 nymph, Joshimath (*c* 1950 m), 26.x.1981, coll. A. K. Mandal; 3 apterous viviparous females, 1 apterous male and 3 nymphs, Lambagar (*c* 2300 m), 28.x.1981, coll. S. Chakrabarti; all from *Populus ciliata* (Salicaceae).

Biological notes: The aphids infest the under surface and sometimes the dorsal surface of leaves of *Populus ciliata*. Coccinellid predators, *Coccinella septempunctata* L., *Halyzia sanscrita* Muls. and *Harmonia eucharis* (Muls.), a syrphid predator, *Metasyrphus latifasciatus* Macg., a dipteran predator, *Leucopis* sp., two chrysopid predators, *Anisochryspa* sp. and *Chrysoperla carnea* (Stephans) and a spider predator, *Marpissa* sp. are collected as associated insects. Black coloured ants are also observed as attendants.



Figs. 7—11. *Nasonovia rostrata* David and Hameed 7—9. Apterous oviparous female : 7. Posterior portion of abdomen; 8. Antennal segment III; 9. Hind tibia; 10—11. Alate male : 10. Posterior portion of abdomen; 11. Antennal segments III and IV.

2. Nasonovia rostrata David and Hameed

Nasonovia (Kakimia) rostrata David and Hameed, 1974. *Orient. Insects,* 8,503; Chakrabarti and Raychaudhuri, 1978. *Entomon,* 3,100.

Nasonovia (Neokakimia) rostrata David and Hameed : Agarwala and Ghosh, 1984. *Rec. Zool. Surv. India,* Occ. paper No. 50, 18.

Nasonovia rostrata David and Hameed : Heie, 1979. *Ent. Scand.*, 9,19.

David and Hameed (1974) described this species under the subgenus *Kakimia.* However, according to Heie (1979) the species having 7 or more hairs on cauda and abdominal spiracles not covered with wrinkled operculum never comes to the subgenus *Kakimia* but remains as a member of *Nasonovia s. str.* Mordvilko. *Nasonovia rostrata* remains distinct in having more than 20 secondary hairs on ultimate rostral segment and first tarsal segment with 3 hairs. Out of known 12 species under the genus, only 2 species viz., *jammuensis* Verma and *rostrata* David and Hameed are known from Western Himalayas as well as from India. Chakrabarti and Raychaudhuri (1978) added a few more characters for apterous viviparous females of *rostrata.* Here, hitherto unknown apterous oviparous female and alate male morphs are described.

Apterous oviparous female (Figs. 7–9): Body 1.54–2.24 mm long and 0.75–1.16 mm wide. Head pale, smooth, dorsum with 8–10 hairs with blunt to incrassate apices on tuberculate bases, the longest anterior discal hair 1.12–1.83 times the b.d. III. Antennae 1.04–1.33 times the body; processus terminalis 6.45–7.33 times the base of segment VI and 1.24–1.37 times the segment III; segment I and II smooth, segment III almost smooth except a few imbrications on basal 0.07 portion, rest of the flagellum gradually imbricated apicad; segment III with 4–6 round, non-protuberant secondary rhinaria in a row distributed over the basal 0.45–0.48 portion of the segment (in one specimen, one side of the antenna contains 5 rhinaria whereas the other side with only 2 rhinaria), with 6–8 hairs having incrassate apices, 30–38 μm in length, 1.0–1.33 times the b. d. III; segments IV and V with 4–5 and 3–5 hairs respectively. u. r. s. 2.29–2.57 times the h. t. 2. Anterior tergites with 4 hairs (2 spinal and 2 marginal), the longest one on 3rd tergite 1.71–2.0 times the b. d. III, 7th tergite with 5–6 hairs and 8th tergite with 6–10 hairs, the longest ones 1.50–1.71 times and 1.50–2.0 times the mentioned diameter respectively. Siphunculi 0.15–0.19 times the body, 1.60–1.88 times the cauda which bears 9–11 long hairs. Hind tibiae with 38–60 pseudosensoria irregularly distributed over the apical 0.60 portion. Other characters as in apterous viviparous female.

Measurements of one specimen in mm: Body length 2.06, width 1.10; antenna 2.24, antennal segments III : IV : V : VI 0.58 : 0.33 : 0.32 : (0.11 + 0.73); u.r.s 0.20; h.t. 2 0.08; siphunculus 0.34; cauda 0.21.

Alate male (Figs. 10–11): Body 2.24 mm long and 0.84 mm wide. Dorsum of head with 8 hairs (2 frontal, 2 anterior discal and 4 posterior discal), longest anterior discal equal to the length of the b.d III. Antennae broken; segments I and II smooth, basal 0.10 portion of the antennal segment III slightly imbricated, rest of the segment smooth, with 37–42 round, slightly protuberant secondary rhinaria, segment IV with indistinct imbrications throughout the segment and with 12 secondary rhinaria; segment III with 21 hairs, longest and shortest ones 1.0 times and 0.71 times the b.d. III respectively; u.r.s. 2.42 times the

h.t.2 and with 24 secondary hairs. Abdomen pale with faint spinal and marginal segmental sclerotic patches on tergites 1–5, anterior tergites with 6–7 dorsal hairs on faint sclerotic bases, the longest and shortest hairs 1.14 times and 0.71 times the b d. III respectively; tergites 7 and 8 with 2 hairs, longest one on 7th tergite 1.28 times and on 8th tergite 1.42 times the b.d. III. Siphunculi pale brown, 6.0 times its maximum width and 0.14 times the body. Cauda with 9 long hairs with a subapical one. Aedaegus elongated, 0.10 mm long, Clasper bifurcated, each with about 16-20 short hairs. Other characters same as in alate viviparous female.

Measurements of the specimen in mm: Body length 2.24, width 0 84; antenna ?, antennal segments III : IV : V : VI 0.79 : 0.51 : ? : ? : u.r.s. 0.21; h.t. 2, 0.08; siphunculus 0.31; cauda 0.13.

Material studied: 1 apterous viviparous female, 4 alate viviparous females, 4 apterous oviparous females and 13 nymphs, INDIA, UTTAR PRADESH, Govindghat (*c* 1829 m), 23.x.1981 and 2 apterous viviparous female, 4 alate viviparous females, 2 apterous oviparous females and 1 alate male, Bhuinder (*c* 2439 m), 23.x.1981, from *Srobilanthes* spp. (Acanthaceae), coll. S. Chakrabarti (Collections with only viviparous morphs are not included here).

Biological notes: The aphids infest the under surface of leaves and the inflorescences.

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MITES ASSOCIATED WITH INSECTS IN TAMIL NADU, INDIA

R. VISHNUPRIYA & M. MOHANASUNDARAM

Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, India 641 003

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The paper presents the occurrence of 7 new species of mites associated with insects in Tamil Nadu. They are *Poecilochirus coimbatorensis* sp. nov. (Poecilochiridae), *Macrocheles scarabae* sp. nov (Macrochelidae), *Pachylaelaps catharsiae* sp. nov. (Pachylaelaptidae) associated with the dung roller beetle, *Catharsius pithecius* F.; *Diplogynium oryctae* sp. nov. (Diplogyniidae) on *Oryctes rhinoceros* Linn. (Scarabaeidae : Coleoptera), *Allothrombium muscaparasiticae* sp. nov. on the housefly *Musca domestica* Linn. (Muscidae : Diptera); *Grandiella batocerae* sp. nov. (Canestriniidae) on the mango stem borer, *Batocera rufoma culata* De Geer (Cerambycidae : Coleoptera) and *Leptus oxyae* sp. nov parasitic on the grasshopper, *Oxya nitidula* Willmese (Acrididae : Orthoptera).

(Key words: mites associated with insects)

In the course of survey and study of mites associated with insects in Tamil Nadu, several mites new to science were discovered. The paper presents the descriptions of seven new species associated with insects along with necessary taxonomic drawings. All measurements given are in micrometers. The types and paratypes slides have been deposited in the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore 641 003, India.

Prasad (1974) catalogued 15 species of mites associated with insects from the Indian region. Later several workers have reported mites associated with insects, especially with reference to honey bees and grasshoppers (Ghai and Ahmed, 1975; Chandra and Mittal, 1981; Rawat, 1981; Putatunda *et al.*, 1983; Bhaskar and Putatunda, 1986; Putatunda and Kapil, 1986a, b). The present report gives information on the mites associated with insects from Southern India.

1. Poecilochirus coimbatorensis sp nov. (Poecilochiridae) (Figs. 1–8)

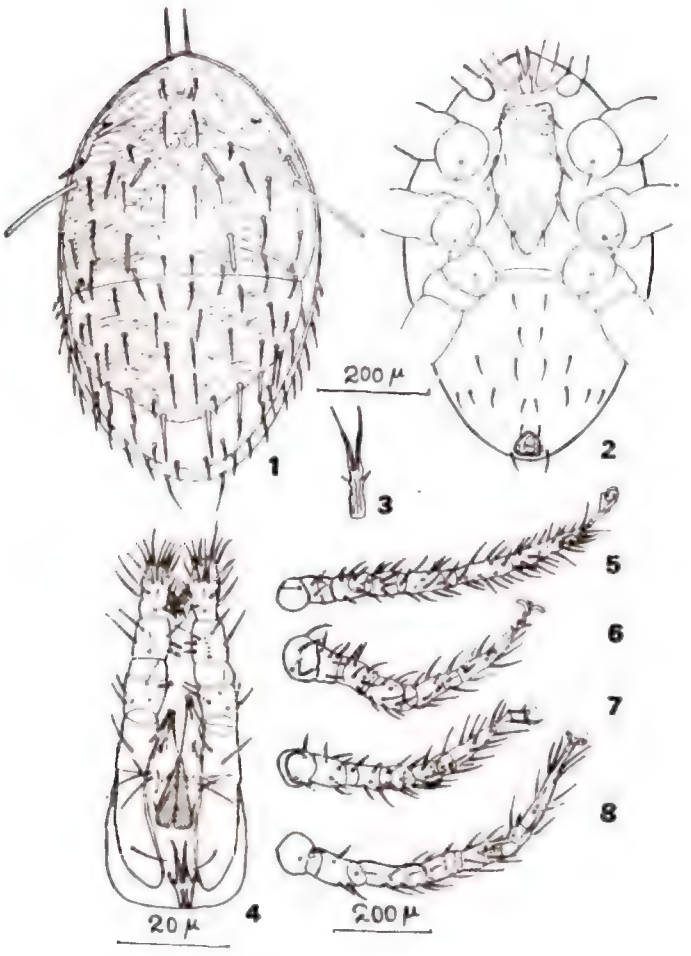
Nymph: Idiosoma 760 long and 470 wide; oval and narrow anteriorly.

Dorsum: The dorsal surface has a rough shield divided into two parts each with faint reticulate pattern. Fiftytwo pairs of setae arise from the dorsal surface. Many of the setae are long and thick.

Ventrum: Has a sternal plate with reticulate pattern; four pairs of setae arise from the sternal plate. Ventral setae are short and simple compared to the dorsal setae. Tritosternum simple and bifid.

Gnathosoma: Well sclerotized, chelicera with dentate blades. The forked seta on the palpal tarsus has three tines. The palpal chaetotaxy is as follows: Coxae–0; trochanter 1; femora–2; genu 5; tibia 6; tarsi–18.

Legs: All the four legs are long. Leg chaetotaxy for I to IV; Coxae–1, 3, 2, 1;



Figs. 1 to 8: *Paecilochirus coimbatorensis*, sp. nov. 1—Dorsal view; 2—Ventral view; 3—Tritosternum; 4—Gnathosoma ventral view; 5—8 Legs I to IV.

trochanter–3, 5, 5, 5; femora–16, 7, 5, 5; genu–10, 8, 8, 11; tibia–11, 8, 8, 10; tarsi–26, 12, 13, 12.

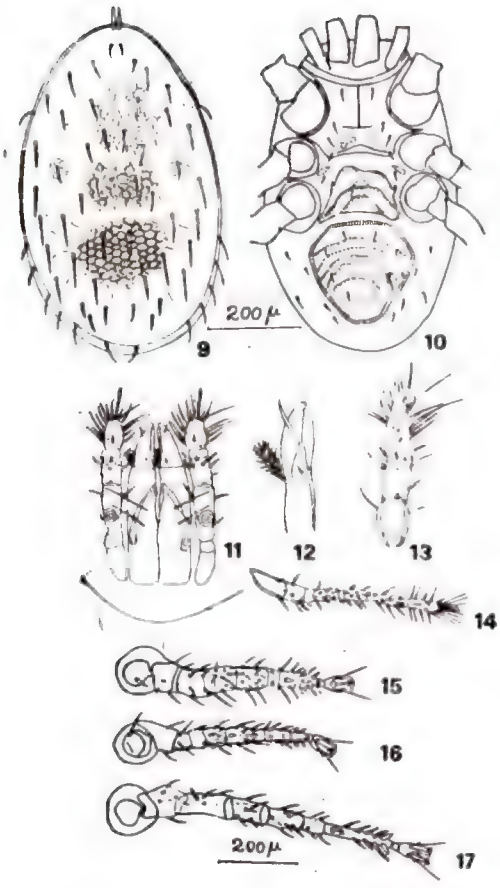
Adults: Not known.

Types: A holotype marked on slide and 3 paratype slides with nymphs; INDIA : TAMIL NADU : Coimbatore, 2.xi.1984, ex *Catharsius pithecius* F. (Scarabaeidae : Coleoptera); Vishnupriya coll.

Remarks: The brown coloured mites are attached to the thorax of the host. This species resembles *Poecilochirus necrophori* (Vitzthum, 1930) in its general appearance and sternal plate, but can be differentiated by the shape of the sternal plate; striation pattern on the sternal plate and 5 pairs of setae arising from the plate and leg chaetotaxy.

2. Macrocheles scarabae sp. nov. (Macrochelidae) (Figs. 9 to 17)

***Female*:** Idiosoma 690 long, 440 wide, oval and narrow anteriorly.



Figs. 9 to 17: *Macrocheles scarabae*, sp. nov. 9—Dorsal view; 10—Ventral view; 11—Gnathosoma ventral view; 12—Enlarged view of chelicerae; 13—Enlarged view of palpal tip; 14 to 17—Legs I to IV.

Dorsum: The dorsal surface covered with a rough shield with faint reticulate pattern, the reticulations being outlined in places by rounded punctations. From the dorsal shield arise 31 pairs of setae.

Ventrum: The ventral surface comprises of sternal, genital and ventro-anal shields. The sternal shield is ornamented with traverse lines and two conspicuous punctate areas lying internal to the third pair of sternal setae. The genital and ventro-anal shields are also ornamented with distinct punctate lines.

Gnathosoma: Well sclerotized, chelicerae with dentate blades.

Legs: All the four legs are tanned; the first pair of legs without pretarsus; pulvillus or claws and terminates into a cluster of setae. The leg IV is longer than legs I to III. Legs chaetotaxy for I to IV: Coxae–2, 1, 1, 0; trochanter–4, 3, 2, 4; femora–9, 7, 4, 4; genu–10, 8, 7, 6: tibia–11, 10, 6, 7; tarsi–23, 18, 15, 17.

Males: Not known.

Types: A holotype female marked on slide and 3 paratype slides, all with females, INDIA; TAMIL NADU: Coimbatore, 20.x.1984 ex *Catharsius pithecius* F. (Scarabaeidae: Coleoptera), Vishnupriya coll.

Remarks: The reddish brown mites are found attached to the body of the host. This species resembles *Macrocheles muscaedomesticae* Scopoli (Hughes, 1976) in its general appearance and colour, but can be differentiated by the presence of fine setae; number of lateral setae and number of dorsal setae arising from the dorsal shield. This species also resembles *M. matrius* Hull (Hughes, 1976) in its ventral aspect but differs in the number of setae on the sternal and ventro-anal shields. This species resembles *M. coprophila* (Womersley, 1942) in its general ventral setation, but can be differentiated by the number of setae present on the sternal, genital and ventro-anal shields. *Macrocheles ontariensis* (Norton, 1973) has three pairs of simple setae on the sternal shield; ventro-anal shield elongate, whereas this species has four pairs of simple setae on the sternal shield and the ventroanal shield nearly trapazoidal.

3. Pachylaelaps catharsiae sp. nov. (Pachylaelapidae) (Figs 18 to 25)

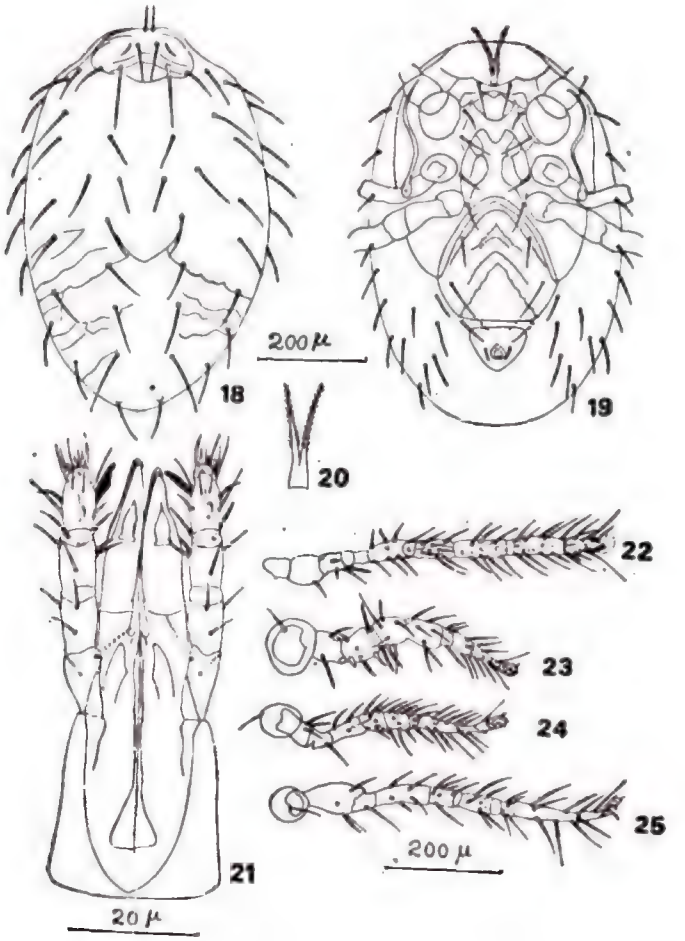
Female: Idiosoma 680 long and 470 wide.

Dorsum: With faint wavy markings and 27 pairs of simple setae arise from the dorsal surface.

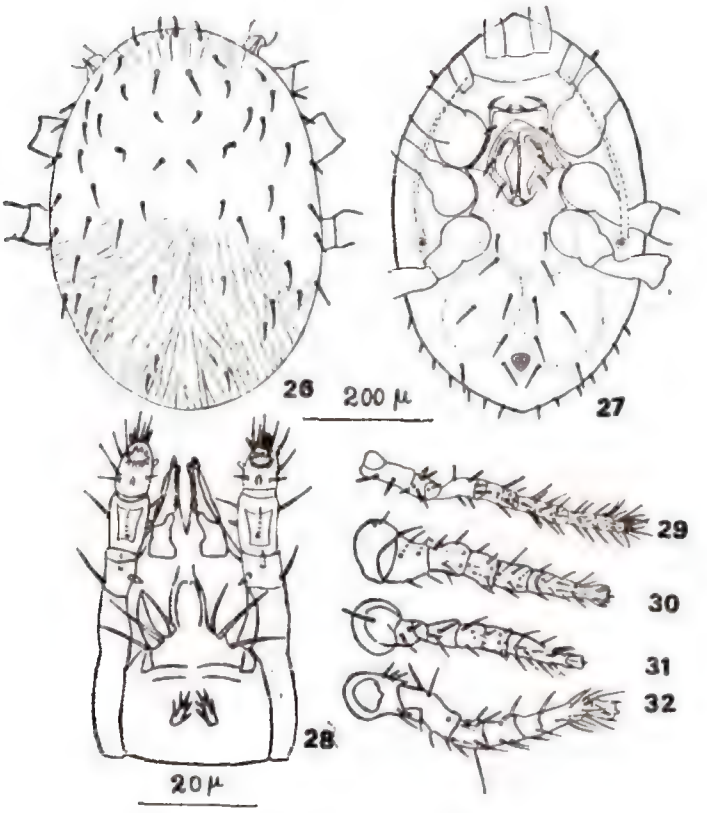
Ventrum: The parapodal, peritremal and metapodal plates are fused into one and extend posterior to coxae IV. The tritosternum hairy and bifid; the sternal shield with lines and light punctations.

Gnathosoma: Elongate, well sclerotized and 310 long; chelae dentate and the forked setae on the palpal tarsus has three tines.

Legs: I and IV longer than II and III. The first pair of legs has no pretarsus, pulvillus, or claws and terminates into a cluster of setae. Other three pairs of legs provided with pretarsi and claws. Leg chaetotaxy for I to IV; Coxae–0, 1, 1, 1; trochanter–1, 2, 3, 3; femora–4, 7, 4, 5; genu–6, 6, 5, 5; tibia–10, 6, 6, 5; tarsi–34, 13, 14, 13.



Figs. 18 to 25: *Pachylaelaps catharsiae*, sp. nov. 18—Dorsal view; 19—Ventral view; 20—Tritosternum; 21—Gnathosama ventral view; 22 to 25—Legs I to IV.



Figs. 26 to 32: *Diplogynium oryctae* sp. nov. 26—Dorsal view; 28—Gnathosoma ventral view; 29 to 32—Legs I to IV.

Males: Not known.

Types: A holotype female marked on slide and 3 paratype slides with females, INDIA; TAMIL NADU: Coimbatore, 20.xi.1984, ex *Catharsius pithecius* F. (Scarabaeidae: Coleoptera), Vishnupriya coll.

Remarks: Brown coloured mites found attached to the legs of the host. This species resembles *Pachylaelaps rotundus* (Berlese, 1910), but can be differentiated by the dorsal setae; leg setation and ventral setation. It is also differentiated from *P. roosevelti* (Wharton, 1941) by the ventro-anal and lateral setation.

4. Diplogynium oryctae sp. nov.
(Diplogyniidae) (Figs. 26 to 32)

Female: Idiosoma 630 long and 430 wide; ellipsoidal in shape.

Dorsum: Marked with definite lines; 31 pairs of short and fine setae arise from the dorsal surface of the idiosoma.

Ventrum: Ventrally, latigynial shields well developed not extending beyond hind margins of coxae III: mesogynial shield fused with the latigynial shields. Ventral setae are fine and simple.

Gnathosoma: Well sclerotized and measures 170 long and 130 wide; cheli-

cerae dentate; a pair of branched setae arise from the base of the chela.

Legs: All the leg tarsi have pulvilli and claws except leg I. The tarsi of leg I terminates into a cluster of setae. Leg III shorter than other three legs. Leg chaetotaxy for I to IV; Coxae-2, 1, 1, 1; trochanter-6, 5, 2, 4; femora-6, 7, 3, 6; genu-7, 8, 5, 8; Tibia-13, 7, 5, 4; tarsi-30, 14, 13, 14.

Male: Unknown.

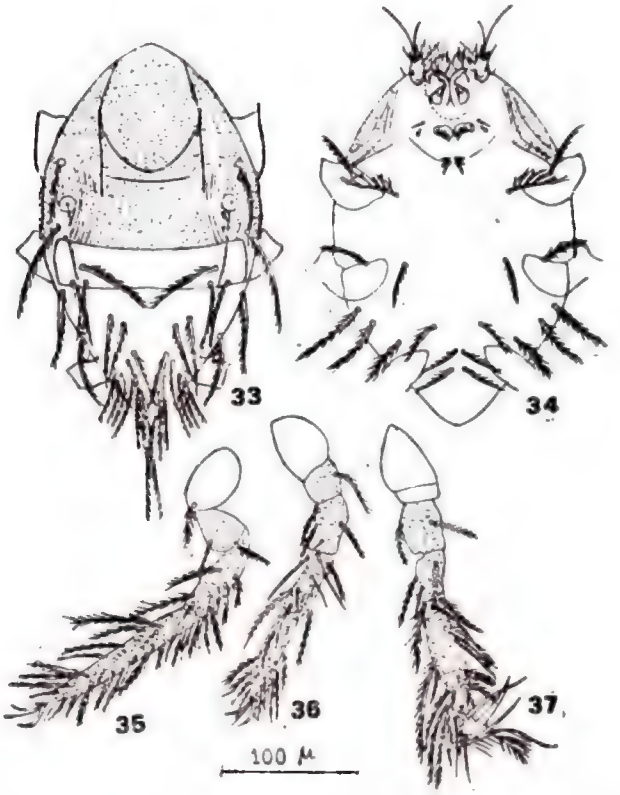
Types: A holotype female marked on slide and 2 paratype slides with adult females; INDIA: TAMIL NADU: Coimbatore; 23.xi.1984, ex. *Oryctes rhinoceros* Linn. (Scarabaeidae : Coleoptera) adults Vishnupriya coll.

Remarks: The brown coloured mites found beneath the elytra of the beetles. This species resembles *Diplogynium tropica* (Oudemans, 1927) in its general appearance, but can be differentiated by the dorsal setation, pattern of lines, ventral setation and leg chaetotaxy.

5. Allothrombium muscaparasiticae, sp. nov. (Trombidiidae) (Figs. 33 to 37)

Larvae: A well built mite, iodiosoma 280 long, 180 wide, widest anteriorly.

Dorsum: The dorsal sheild marked with fine punctations in the middle and longitudinal undulating lines on the sides. Dorsal setae long with dense plumose hairs.



Figs. 33—37: *Allothrombium muscaparasiticae*, sp. nov. 33—Dorsal view; 34—Ventral view; 35 to 37—Legs I to III.

Ventrum: The chelicera placed in a cavity; palpi short and stubby; ventral setae short with plumose hairs, the secondary hairlets with which they are furnished being of moderate length.

Legs: Three pairs of legs; all leg tarsi with pulvillus and two claws. Setae long and plumose. Leg chaetotaxy for I to III; Coxae–1, 0, 0; trochanter–1, 1, 2; femora–5, 4, 3; genu–6, 3, 3; tibia–7, 6, 4; tarsi–13, 12, 12.

Adults: Not known.

Types: A holotype marked on slide and two paratype slides with larvae; INDIA: TAMIL NADU: Coimbatore; 4.iii.1985; ex *Musca domestica* L. (Muscidae : Diptera) Vishnupriya coll.

Remarks : This species resembles *Allothrombium neapolitanum* Oudemans (1927), in its general appearance but can be differentiated by the dorsal setation and shape of the dorsal shield. *A. wyandrae* (Hirst, 1928) also resembles this species but can be differentiated by the leg chaetotaxy and dorsal setation.

Biological observations and review:

The species *Allothrombium muscaparasiticae* sp. nov. are found in the moist litter and debris. The red coloured mites may be found attached to the abdomen and squamae of the bouseflies. The life stages of this mite are egg, deutovum, larva, nymphochrysalis, nymph, imagochrysalis and imago. The larval stage is ectoparasitic on houseflies. It attaches to any part of the housefly with the aid of powerful curved chelicerae and sucks the haemolymph. They attain the nymphochrysalis stage within 3 to 5 days and detaches from the host.

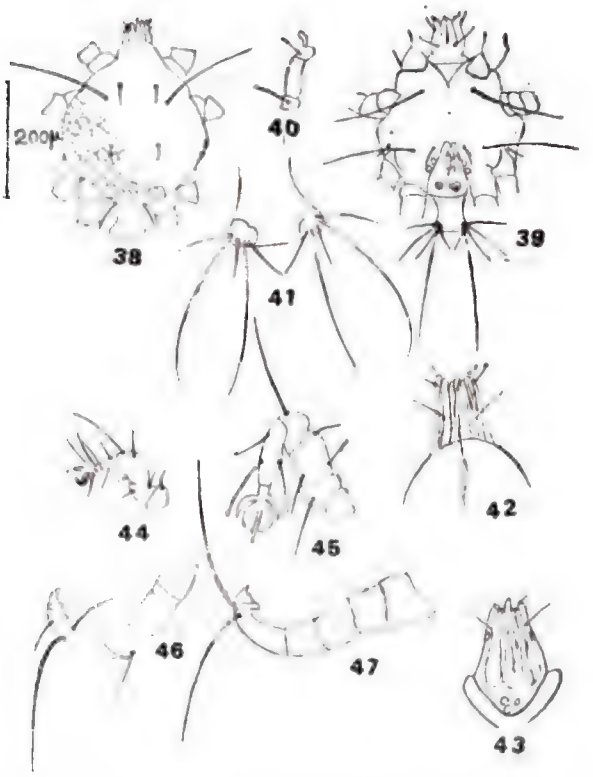
Earlier, several Macrochelidae have been recorded on the housefly, *Musca domestica* and attempts to use these mites for their biological control has been made. The macrochelids feed on housefly eggs, and Pereira and de Castro (1945) suggested their use in biological control of house flies. All but the first instar of *Macrocheles muscaedomesticae* Scopoli fed on housefly eggs. Pereira and de Castro (1947) found that the adult female mites were phoretic on the adutt housefly and reproduced by arrhenotokous parthenogenesis. Filipponi (1955) reevaluated the nature of association between *M. muscaedomesticae* and the housefly and confirmed that the mite attacked mostly the eggs and first instar larvae of the housefly. Wade and Rodriguez (1961) reported a detailed account of the life history of *M. muscaedomesticae*. Axtell (1963) studied the effect of macrochelids on housefly multiplication in outdoor manure pits and found it to give better control of flies than manure pits without mites. This species also fed on eggs of the stable flies, *Stomoxys calcitrans* (L) (Williams and Rogers, 1976). *M. eurygaster* and *M. peregrinus* were reported to be good biological control agents of the fly pests, *Musca vetustissima* (Wlk.) and *Haematobia exiguae* (de Meijere) in Australia (Krantz, 1981).

6. Grandiella batocerae sp. nov. (Canestrinidae) (Figs. 38 to 47)

Female: Dorso-ventrally flattened, broad, hairy, 400 long including gnathosoma, 250 wide.

Dorsum: With a broad blunt shield over rostrum base, finely reticulate; propodosoma with one pair of long setae 133 long, and one pair of short setae, 11 long. Base of the abdominal tip with a pair of short lateral setae. Abdominal tip club-shaped projecting below the fourth pair of legs.

Ventrum: Gnathosoma with a pair of setae 11 long; a pair of long setae at the base of coxae I and coxae III measuring 44



Figs. 38 to 47 : *Grandiella batocerae* sp. nov. 38—Dorsal view; 39—Ventral view; 40—Palpi; 41—ventral view of abdominal tip; 42—Dorsal view of gnathosoma; 43—Ventral view of gnathosoma; 44 to 47—Legs I to IV.

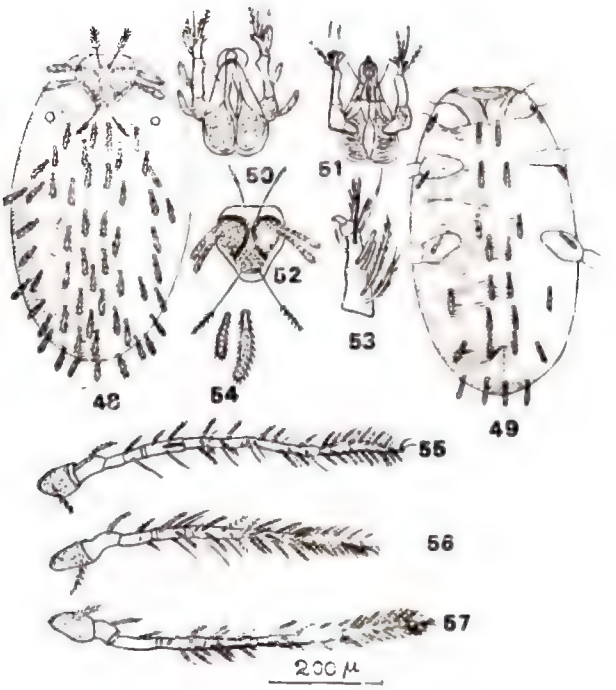
and 55 long respectively. Abdomen with two pairs of genital suckers and one pair of anal sucker. Abdominal tip with a cluster of five setae on each side arranged over tubercular enlargements.

Leg chaetotaxy for I to IV: Coxae–1, 0, 0, 0; trochanter–2, 1, 0, 0; femora–2, 3, 0, 0; genu–1, 1, 1, 0; tibia–5, 3, 2, 1; tarsi–1, 0, 1, 1;

Male: Not known.

Types: A holotype female marked on slide and a paratype slide with females, INDIA: TAMIL NADU: Coimbatore, 23.vii.1984, ex *Batocera rufomaculata* De Geer. (Cerambycidae: Coleoptera); Vishnupriya coll.

Remarks: White mites found beneath the elytra of the adult beetles. The present species resembles *Grandiella escaudata* (Lombardini, 1938) in its general appearance, but can be differentiated by the dorsum. In *G. escaudata* dorsum is ornamented with fine punctations while in the present species, there is a fine reticulated pattern of lines in the dorsum. It is also differentiated by the five pairs of setae found at the ventral abdominal tip which is quite narrow as compared with the abdominal tip of *G. escaudata*.



Figs. 48—57 : *Leptus oxyae*, sp. nov. 48—Dorsal view; 49—Ventral ciew; 50—Dorsal view of gnathosoma; 51—Ventral view of gnathosoma; 52—Enlarged view of the dorsal scutum; 53—Enlarged view of palpal tip; 54—Ventral setae and dorsal setae; 55 to 57—Legs I to III.

7. Leptus oxyae sp. nov. (Erythraeidae) (Figs. 48 to 57)

Larvae: Idiosoma ovoid, flattened below, 800 long and 330 wide.

Dorsum: The dorsal surface with characteristic striations, actuely angled in two rows near the margins. Dorsal scutum triangular with broadly rounded angles with fine punctations, two pairs of broad hairy setae on the anterolateral angles and two pairs of fine serrate setae (sensillary setae) in the anterior and posterior ends. The sensillary setae fine, tapering and with spines in the distal end. Dorsum of iodiosoma with 54 setae, slightly expanded distally, arranged in rows as dorsal, subdorsal, doro-lateral and lateral rows along with 2 setae on the median line. Each seta measures 60 long

Ventrum: Ventral surface also with characteristic but wavy striations. idiosoma with 8 pairs of median setae and 3 pairs of sub-lateral setae. All setae slightly expanded distally, arranged in rows. Each seta measures 50 long.

Gnathosoma: 210 long, 110 wide, dorsum finely punctate, chela base rounded posteriorly and narrowed anteriorly with one pair of short setae laterally and one pair of long setae ventraily towards the tip. Palpi ends abruptly and characteristically bent; palpal tibial claw simple. Gnathosoma as well as palpal base ventrally with fine, indistinct scorings.

Legs: Three pairs, elongated and taperings; Leg I and III longer than leg II, all legs bear two claws. Leg chaetotaxy for I to III; Coxae–1, 1, 1; trochanter–1, 1, 1; femora–6, 7, 6; genu–7, 7, 8; tibia–10, 14, 9; tarsi–20, 20, 20.

Adults: Not known.

Types: A holotype marked on slide and two paratype slides each with 2 specimens: INDIA: TAMIL NADU: Coimbatore; 16.x.1984; ex. *Oxya nitidula* Willmese (Acrididae : Orthoptera).

Remarks: The reddish mites are found attached to the leg region. The genus *Leptus* is known on a world-wide basis (Southcott, 1961). A large number of species are described from the larval instar only. *Leptus oxyae*, sp. nov. may be distinguished from all previously described larval species based on the scutum, body setae, leg setation, palpal setae and other gnathosomal characteristics. It differs from *L. asahinai* (Kawashima, 1958) in having expanded dorsal setae and in the number of the dorsal setae, being 54 instead of 74 present in the later species. It is differentiated from *L. galerucae* (Feider, 1967) in numerous characters; the latter species has a very broad setae and the idiosoma bears dorsally about 108 setae; the central ventral setae are directed anterior to the third intercoxale.

Among the South-eastern European species considered by Beron (1975) this species apparently resembles *L. ignotus* (Beron) but can be differentiated by the number of dorsal setae. It also resembles *Leptus draco* (Southcott, 1984) in its general appearance and the shape of the dorsal scutum but can be differentiated by the setal pattern both on dorsum and ventrum.

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A NEW GENUS AND SPECIES OF ERIOPHYID MITE FROM WEST BENGAL (ERIOPHYIDAE : ACARI)

M. MOHANASUNDARAM & PRADEEP SINGH[1]

Department of Entomology, Tamil Nadu Agricultural University, Coimbatore, India 641 003

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The paper presents an account of a new genus and species of eriophyid mite, viz., *Notacaphylla chinensiae* n. gen. sp. vagrant on leaves of *Litchi chinensis* Sonnerat from West Bengal.

(Key words: eriophyid, *Notacaphylla, Litchi*)

In the course of collection and study of phytophagous mites, a new species of eriophyid was encountered on *Litchi* leaves. Generally *Aceria litchii* Keifer (1943) occurs throughout India whenever litchi is grown, causing the characteristic erineum which turns brick red later with the deformation of the leaves. The present species is vagrant on the lower side of the leaves, causing slight rusting and characterised by five wax bearing lines on the dorsum of the abdomen as well as wax ridges on the cephalothoracic shield. The study of the specimens revealed it to be near the genus *Acaphylla* but did not fit into it due to certain different characters. Hence, the new genus is proposed to hold this species. All measurements given are in micrometers. The slides containing the holotype and paratypes are deposited in the collection of the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore, India 641 003.

Notacaphylla new gen.

Shield broadly triangular, anterior lobe overhanging rostrum base, tip of the lobe acute; dorsal tubercles set ahead of rear margin, tubecles elongate with a broad base, the dorsal setae, coarse and thick, pointing upwards and backwards. Rostrum small, projecting down, coxae with seta I missing. Both legs with femoral, patellar and tarsal setae. Feather claws divided and claws knobbed at tip. Abdomen with a mid dorsal and a subdorsal ridge on either side, almost reaching the telosome; tergites smooth, sternites microtuberculate. All abdominal setae present except the accessory seta. Female genital coverflap with longitudinal ridges.

Type species Notaoaphylla chinensiae n. sp.

This genus resembes *Acaphylla* Keifer (1943) by its general shape, absence of coxal seta I and divided feather claws. It is differentiated from *Acaphylla* by the dorsal and subdorsal ridges; elongated dorsal tubercle with rough and thick seta and the presence of the patellar seta in the hind leg.

[1] Department of Agriculture, Camp Bell, Port Blair, The Andamans.

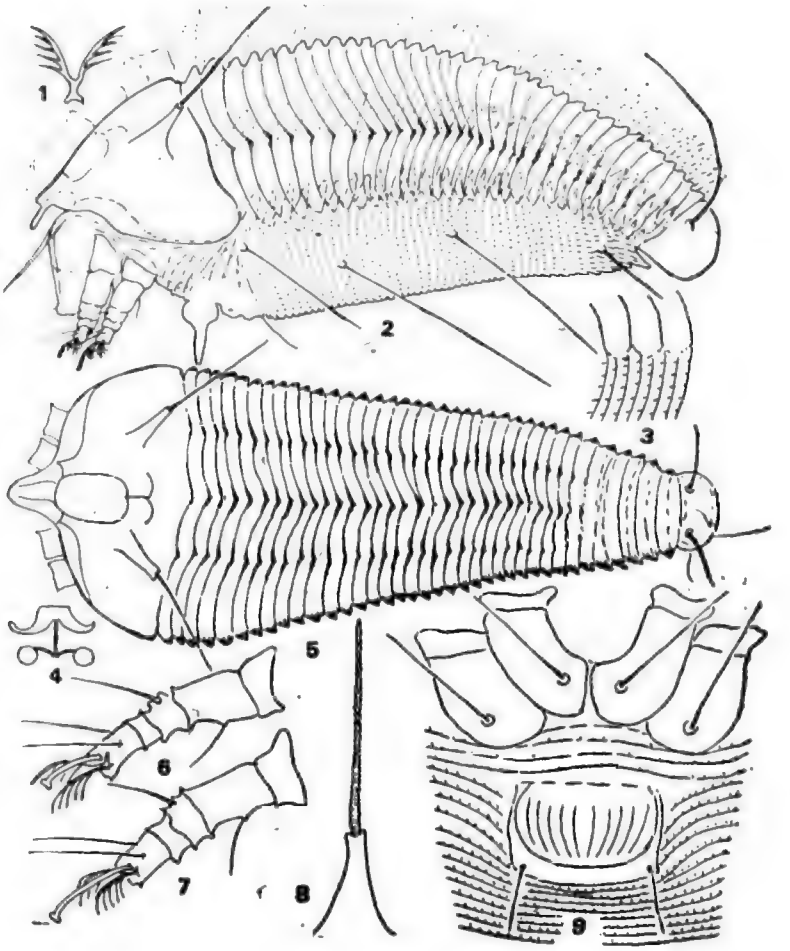

Fig. 1. *Notacaphylla chinensiae* gen. et. sp. nov. 1. Feather claw; 2. Side view of mite showing wax flakes in dotted lines; 3. Side skin structure; 4. Internal female apodeme; 5. Dorsal view of mite; 6. Left fore leg; 7. Left hind leg; 8, Dorsal tubercle with seta; 9. Ventral view of coxae and female genitalia.

Notacaphylla chinensiae n. sp. (Fig. 1)

Female : Wedge shaped, tapering posteriorly, 160 long, 60 wide, rostrum 17 long, pointing downwards antapical seta 4 long, cephalothoracic shield broadly triangular, with an acute lobe overhanging rostrum base; median absent, abmedians forming an elongate oval cell in the anterior half and forking anteriorly and curving out posteriorly. Submedians represented in the anterior region forming the border of the shield. Dorsal tubercles much ahead of shield margin, 25 apart, 10 long with a broad base; dorsal setae, rough, thick, 28 long pointing upward and backward. Both legs with femoral, patellar and tarsal setae; feather claws divided with 5 rays in each. Foreleg 20

long, tibia 2 long; tibial seta absent; tarsus 5 long, claw 5 long, curved with a knobbed tip; feather claw divided with 5 rays in each; hind leg, 18 long, tibia 2 long, tarsus 5 long, claw 8 long, similar to foreclaw. Coxae with the seta I missing; coxal area smooth.

Abdomen with about 36 smooth tergites and about 60 microtuberculate sternites; dorsum with a mid dorsal ridge and a subdorsal ridge on either side; the three ridges and lateral sides with wax flakes while alive. Lateral seta 24 long on sternite 6; first ventral seta 40 long on sternite 18; second ventral seta 30 long on sternite 36; third ventral seta 13 long on sternite 5 from behind; caudal seta 55 long; accessory seta absent. Female genitalia 20 wide, 12 long; coverflap with 8–10 lines; genital seta 8 long.

Male : Not known

Types : A holotype ♀ marked on slide, and 5 paratype slides, all with ♀♀; INDIA : WEST BENGAL ; KALYANI, 10.ii.1987 ex. *Litchi chinensis* Sonnerat (Sapindaceae) Pradeep Singh Coll. (No. 548) TNAU.

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ORGAN-SPECIFIC QUANTIFICATION OF ACID- AND ALKALINE PHOSPHATASE OF *ALPHITOBIUS PICEUS* OLIVIER (INSECTA : COLEOPTERA : TENEBRIONIDAE) DURING POST-EMBRYONIC DEVELOPMENT

CHINMOY CHATTERJEE & SUBRATA ROY

Insect Physiology Laboratory, Zoology Department, University of Burdwan
Burdwan, India 713 104

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The activity of the enzymes acid- and alkaline phosphatase in the whole body, fat body, gut and integument during the post-embryonic development at controlled condition is presented. During each moulting cycle the activity of acid phosphatase increased gradually from early to late period of each larval stage in the whole body, fat body and gut. But in the integument an initial decline in the intermoult period followed by a significant increase in the premoult period was observed. Alkaline phosphatase in all the cases exhibited a gradual increase during each moulting cycle. In the pupal period the activity of acid phosphatase in the whole body and integument showed a gradual increase with age while the activity in the gut declined gradually. In the fat body the activity showed an initial increase followed by a decline. The activity of alkaline phosphatase in almost all the cases declined gradually with the pupal age. The possible physiological significance of these findings have been discussed.

(Key words: biochemistry, physiology, alkaline phosphatase, acid phosphatase, moulting cycle, *Alphitobius piceus)*

INTRODUCTION

The physiological role of the phosphatases in insects is not as well understood as that of other enzymes. Considerable work on the activity of phosphatases in insects during their post-embryonic development has been done. Alkaline and acid phosphatases have been shown to be associated with insect development, especially in relation to nutrition and egg maturation (LUDWIG *et al.*, 1962; NATH & BUTLER, 1971; RENAUD, 1949). But most of the investigators reported the gross alterations of acid- and alkaline phosphatases in the body as a whole. Very scanty information with regard to fluctuation of these phosphatases in different parts of insect body during post-embryonic development are available. In this communication an attempt has been made to record the fluctuation of acid and alkaline phosphatases in the gut, fat body and in the integument of a minor coleopteran stored grain pest *Alphitobius piceus*.

MATERIALS AND METHODS

Culturing of the insects: Both the adults and larvae of *A. piceus* were collected from damp and stacky grains of a neighbouring F C I warehouse. The insects being photophobic, were kept after collection in a large black glass jar filled with fresh wheat. To the culture medium 2% Nepazin was added to avoid fungal infection. The larval period

of the insects showed six instars. Late sixth instar larvae were separated from the sample and kept into another jar. They soon developed into pupae. After six days pupae developed into adults. Intermoult days were identified as early, mid and late periods on the basis of age and external characters. The first day after the preceding moult was considered as the early, the intermediate days as mid and the last day as the late instar periods. Cultures were maintained at 28±2°C and 80% RH in complete darkness in a B O D incubator.

Enzyme activity assay: Enzyme activity assay of acid- and alkaline phosphatases in the whole body homogenate were done from second instar onward. Organ specific estimations were carried out from the fifth instar onward only due to difficulty of dissecting out the organs in the early instars. Firstly the larvae and adults were starved for 3 h. After dissection in the Ringer's solution (in ice cold condition) the integument, the gut and the fat body from 10–15 larvae (depending on the developmental stages) were pooled for single assay. The tissue samples were homogenised separately in ice cold glass double distilled water and processed for the enzyme activity assay. Enzyme activities were determined by Sigma colorimetric determinations at 37°C after 30 min incubation (Sigma Chemical Company, 1982) using disodium *p*-nitrophenyl phosphate as substrate.

Enzyme unit: Here the unit of enzyme is defined as the amount that catalyses the cleavage of 1 μ mol of substrate (or bond) per minute.

RESULTS

The data (Figs. 1 and 2) depict fluctuations in the activity of acid- and alkaline phosphatase in the total body and in various organs during post-embryonic development. The fluctuations showed a more or less definite pattern. Organ specific variation in larvae showed (Fig. 1) highest acid phosphatase activity (as % of the acid/alkaline phosphatase activity in the whole body homogenate) in the fat body (20.45%—50.43%) followed by the gut (18.10% — 44.78%) and the integument (8.21% — 18.62%). Similarly highest alkaline phosphatase activity was found in the gut tissue (25.30%—44.99%) followed by the integument (13.88% — 44.92%) and the fat body (7.00%–24.73%).

In the larval life the acid phosphatase activity increased from early to late periods during each moulting cycle in the whole body homogenate (Fig. 2), fat body and in the gut (Fig. 1) while the activity in the integument decreased (14.36% in 5th instar and 23.44% in 6th instar) from the early to mid periods and increased significantly (92.5% in 5th instar and 95.21% in 6th instar) in the pre-moult or late periods. The alkaline phosphatase activity in almost all the cases increased gradually from early to late larval periods.

During the pupal life acid phosphatase activity increased gradually from early to late periods in the whole body homogenate and in the integument. In the fat body the activity increased significantly in the intermoult period (83.66%) but declined (63.67%) before the larval–pupal moult. In the gut tissue the acid phosphatase activity declined gradually from early to late pupal period. The enzyme activity in the adult showed a slight increase in comparison to that in the late pupal stage in all cases. A gradual decline in the alkaline phosphatase activity with the pupal age was found in the whole body, fat body, gut and integument. These declining trends were also observed in the fat body, gut and integument in adult. While the activity increased in the whole body homogenate.

DISCUSSION

The results indicate that both the enzymes exhibited specific fluctuation in different organs. The increased activity of acid phosphatase in whole body, fat body and gut tissue during larval period might

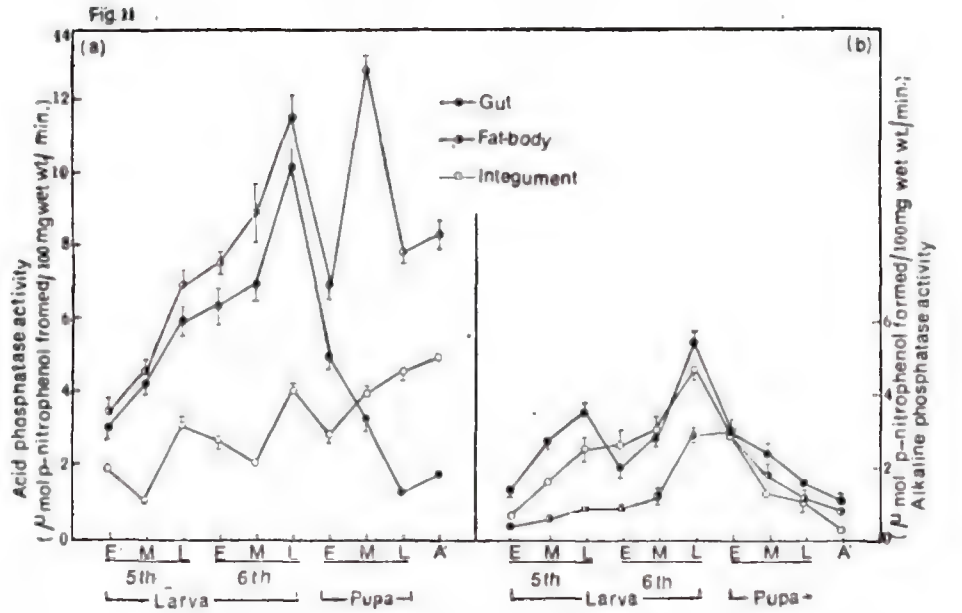

Fig. 1. Changes in the acid phosphatase (A) and alkaline phosphatase (B) activity in the gut, the fat body and the integument in different morphogenetic periods of the post-embryonic development of *Alphitobius piceus*. 'E', 'M' and 'L' denote early, mid and late stage respectively. A' denotes newly emerged adults.

be due to accumulation of lysosomes ultimately leading to lysis and celll death during metamorphosis (TYSELL & BUTTERWORTH, 1978). The enhanced enzyme activity towards late larval period of each moulting cycle was probably due to increased moulting hormone titre followed by autophagic aud heterophagic processes (AIZENZON *et al.*, 1975; SASS & KOVACS, 1975, 1977; DELOACH *et al.*, 1981). Phosphatases are important enzymes related to transport of materials across membranes. High rate of food consumption and subsequent absorption in larval stage probably led to an enhanced activity of acid phosphatase (LUNDSGAARD, 1963; SRIDHARA & BHAT, 1963; PANT & SRIVASTAVA, 1978). Substantial rise in this enzyme activity during each premoult period corroborates with the findings of RENAUD (1949) and might be due to release of the enzyme from degrading layer of old cuticle (RIDDIFORD & TRUMAN, 1978) during apolysis.

The increased activity of alkaline phosphatase with larval age might be due to its association with cell proliferation (WILLMER, 1952) and it probably facilitated differentiation and organogeny in larval forms (PANT & KUMAR, 1981). The higher rate of absorption and transport of metabolites probably led to an enhanced alkaline phosphatase activity level in gut tissue and similar result was also obtained by NATH & BUTLER (1973).

The enhanced activity of acid phosphatase in the whole body, fat body, and integument during the first half of

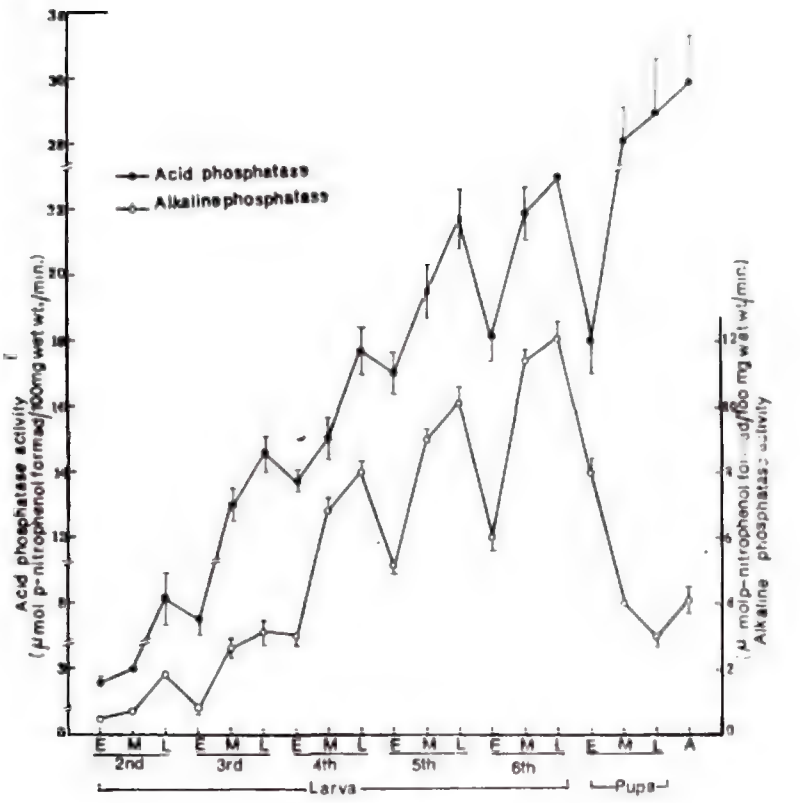

Fig. 2. Changes in the activities of acid (abscissa left) and alkaline (abscissa right) phosphatases in the whole body of *Alphitobius piceus* during its post embryonic development. 'E', 'M', and 'L' denote early, mid and late periods of each moulting cycle. 'A' denotes newly emerged adults.

the metamorphosis was possibly associated with histolytic processes (DELOACH & MAYER, 1979) and a decline thereafter in the fat body suggests the synthetic activities during histogenic phase. In the whole body and integument, however, the increased acid phosphatase activity during the late pupal period is contradictory to its degradative actions and might be due to differentiation of imaginal structures (MATHAI & NAIR, 1982). A gradual clearence of this enzyme from pupal gut may be dne to its relative quiescence condition. The same reason may be attributed to the gradual decline in the alkaline phosphatase activity in almost all the cases during metamorphosis.

The increased activities of acid phosphatase in the aduls possibly suggests the begining of cell necrosis and autophagy in this stage. Similarly, the increased activity of alkaline phosphatase in the whole body during this time may be due to gametic maturation (NATH & BUTLER, 1973) while the reason for the decline in the fat body, gut and integument is obscure.

Acknowledgements: Authors are grateful to the Head of the Zoology Department, Burdwan University for providing necessary laboratory facilities and other required assistances for this investigation.

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RELATIONSHIP BETWEEN CERTAIN ABIOTIC AND BIOTIC FACTORS AND THE OCCURRENCE OF GRAM POD BORER, *HELIOTHIS ARMIGERA* (HBN) ON CHICKPEA

C. P. YADAVA & S. S. LAL

Directorate of Pulses Research (ICAR), Kanpur, India 208 024

(Received 5 January 1988)

The larval population of *Heliothis armigera* occurred on chickpea almost throughout its growth phase, being low at the vegetative and flowering stage and high at the grain development stage. There were two larval peaks, first between 47–50 standard week and between 11-15 standard week. The correlation coefficients were found to be positively significant in case of maximum and minimum temperatures but were negatively non-significant with relative humidity and per cent parasitization. Coefficient of determination (R^2) revealed that all the four factors i. e., maximum and minimum temperatures, relative humidity and parasite activity contributed nearly 61 and 44% of the total larval variations during 1982–1983 and 1983-1984, respectively. This indicates a need to investigate further on other factors responsible in regulating the larval population.

(Key words: Gram pod borer, *Heliothis armigera*, larval population, abiotic and biotic factors)

INTRODUCTION

The gram pod borer *Heliothis armigera* (Hubner) (Lepidoptera : Noctuidae) is a serious pest of pulses responsible for heavy crop losses. Field surveys in 35 districts of Uttar Pradesh during 1979–1982 revealed that on an average the mean pod damage in chickpea due to *H. armigera* was found to be 14.8 per cent (LAL *et al.*, 1985). LATEEF & REED (1983) reported that in different states of India, mean pod damage in pigeonpea during 1975–1981 due to lepidopteran borers, mainly *H. armigera* was recorded to vary from 13.2 to 36.4%. The epidemic outbreak of gram pod borer is reported to occur at irregular intervals (VAISHAMPAYAN & VEDA, 1980). The environmental factors that regulate cyclic occurrence are of considerable importance to understand the trend of population build-up of the pest. A few workers (VAISHAMPAYAN & VEDA, 1980; KAUSHIK & NARESH, 1984) have made attempts to study the ecology of the pest in certain parts of the country. Since the validity of such findings is area specific and no such studies have so far been taken in and around Kanpur, the present studies followed. This paper reports the results of analysis of 2 years data of the pattern of numerical changes in larval population of *H. armigera* and its relationship with the effective environmental factors including weather conditions and the activity of its major larval parasite, *Campoletis chloridae*.

MATERIALS AND METHODS

The larval population of all ages was collected from chickpea fields at weekly intervals at the farm of Directorate of Pulses Research, Kanpur. Chickpea cultivar 'L 550' was used throughout the study. The plot was divided into 10 equal quadrants and from each quadrant, an area of 1 sqm was used as sampling

unit controlling the larval population. Collected larvae were reared in the laboratory individually to observe the extent of parasitization. Mean maximum and minimum temperatures (°C) and mean relative humidity (%) were collected for the full observation period and used for analysis.

RESULTS AND DISCUSSION

Weekly larval population of *H. armigera* and its per cent parasitization in relation to temperature and relative humidity are shown in Figure 1. It is seen from results that the larval population of H. *armigera* occurred on chickpea almost throughout its growth phase, being low at the vegetative and flowering but high at the grain development stage, during both the years. The population during 1982–1983 was below 10 larvae / 10 m² till 10th standard week, rose to 19 larvae / 10 m² by 11th standard week and attained its peak (23 larvae / 10 m²) in the 12th standard week. The population decline was observed thereafter and it was nil on 18th standard week. Similar trend was observed during second year.

It is clear from the results of two years data that there were two larval peaks of *H. armigera*, first between 47–50 standard week i. e., in December and the second between 11–15 standard week. It is the

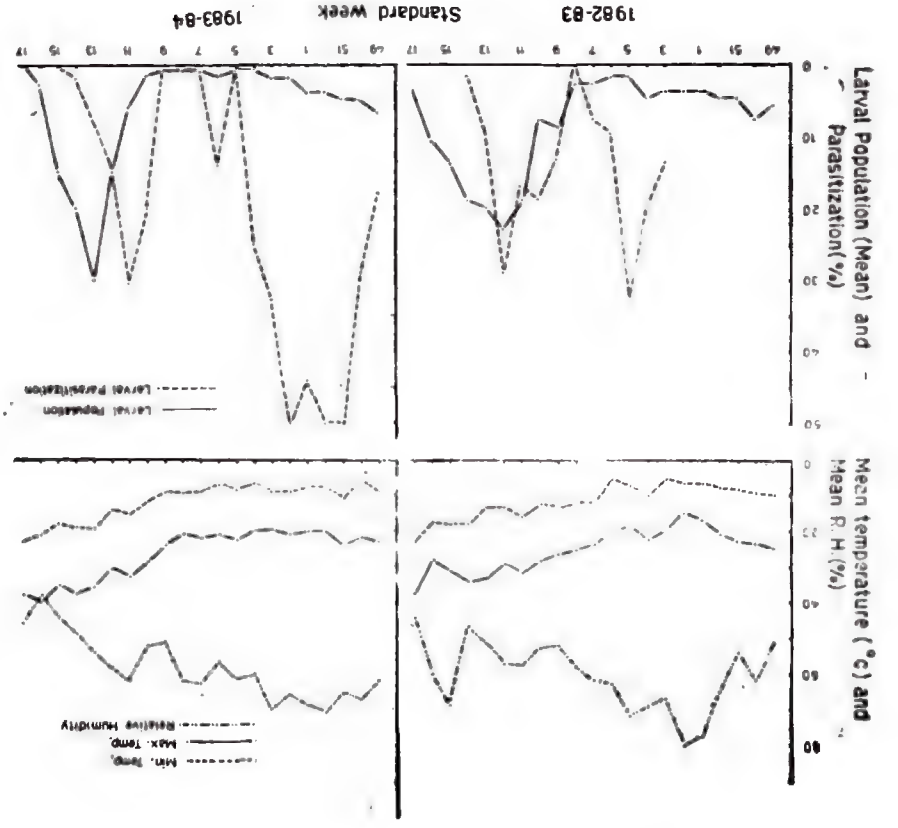

Fig. 1. *Heliothis armigera* larval population and its per cent parasitization in relation to temperature and relative humidity.

TABLE 1. Multiple (R) correlations between larval population of *H. armigera* and mean environmental parameters and per cent parasitization due to *C. chloridae* in chickpea for eighteen observation periods.

Statistics	Parameters							
	Abiotic						Biotic	
	Maximum temperature mean (°C)		Minimum temperature mean (° C)		Relativie humidity (%)		Per cent paratization (mean)	
	1982—83	1983—84	1982—83	1983—84	1982—83	1983—1983	1982-83	1982-84
R	0.65**	0.54*	0.68*	0.55	0.77*	0.65	0.78	0.66
R^2 (%)	42	29	47	30	60	43	61	44
b	2.25**	1.93*	—1.28*	—1.01	0.43*	0.70	—0.06	—0.07

*Significant at 5% level; **Significant at 1% level. R^2 = Percentage of variation in dependent variable (Y) explained by variation in independent variables (Xi); b = partial regression coefficient values.

TABLE 2. Multiple (R^2%) correlations between per cent parasitization of *H. armigera* larvae due to *C. chloridae* and mean environmental parameters in chickpea for eighteen observation periods.

Statistics	meteorological parameters					
	maximum temperature mean (°C)		minimum temperature mean (°C)		relative humidity (%)	
	1982—83	1983—84	1982—83	1983—84	1982—83	1983—84
R	0.35	0.53	0.58	0.52	0.57	0.72
R^2 (%)	11	26	30	28	31	56
b	3.38	0.64	—4.81	0.14	0.26	1.99

R^2 Coefficient of determination (%). b Partial regression coefficient values.

second peak that inflicted crop losses in chickpea.

VAISHAMPAYAN & VEDA (1980) reported that the population build up of *H. armigera* larvae was correlated positively with rainfall and minimum temperature and negatively with relative humidity. The correlation between activity of parasite, *Campoletis perdistinctus* (Vier) and larval population of *H. armigera* was positive during 1975–1977 and negative during 1977–1978. They concluded that rainfall and relative humidity played major role in population build up of *H. armigera* in Madhya Pradesh. Similar observations were made by KAUSHIK & NARESH (1984) in Haryana.

The findings on multiple correlations R (Table 1) revealed that maximum temperature had a high positive association with larval population of *H. armigera* (R = 0.65), with the addition of minimum temperature, R increased to 0.68. By including relative humidity, R increased to

TABLE 3. Estimates of correlation coefficient (r) between larval population of *H. armigera*, per cent parasitization due to *C. chloridae* and mean weather parameters for two years.

Year	Meteorological parameters			Per cent parasitization (mean)
	Maximum temperature mean (°C)	Minimum temperature mean (°C)	Relative humidity %	
1982—83	0.65*	0.68*	−0.77	−0.78
	(−0.1176)	(−0.2128)	(0.1207)	—
1983—84	0.54**	9.55*	−0.65	−0.66
	(−0.5007**)	(−0.4390*)	(0.7000**)	—

Figures without parenthesis are the r values between larval population and the respective parameters. Figures within parenthesis are the r values between per cent parasitization and the respective characters. * Significant at 5% level. ** Significant at 1% level.

0.77 and then to 0.78 with the inclusion of per cent parasitization due to *Campoletis chloridae* during the year 1982–1983. A similar trend followed in second year. The correlation coefficients were found to be positively significant in case of maximum and minimum temperature but were negaively non-significant with relative humidity and per cent parasitization (Table 3).

In order to quantify the relative role of various parameters coefficient of determination (R^2) was worked out. It is evident from Table 1 that maximum temperature contributed 42%, minimum temperature 5%, relative humidity 13% and per cent parasitization 1% of the total variation in larval population of *H. armigera* during 1982–1983. The R^2 values for the year 1983–1984 were 29, 1, 13 and 1 per cent for maximum and minimum temperatures, relative humidity and per cent parasitization, respectively. In total these parameters accounted for 61 and 41% of the total variations in larval populations of *H. armigera* during both the years, respectively.

The activity of larval parasitoid, *Campoletis chloridae* on *H. armigera* was found to be promising, the parasitization being 33 to 50 per cent. The per cent parasitization was found to be significantly negatively correlated with maximum and minimum temperatures and positively with relative humidity during 1983–1984. A simiar trend was observed during second year but correlations were nonsignificant (Table 3). The partial regression coefficient values were found to be nonsignificant (Table 2).

The above study indicates that the contribution of weather parameter to the total variation in larval population is more. There is negligible improvement in total variation in larval population by incorporating larval parasite in the prediction equation. The low R^2 values (61 and 41% during 1982–1983 and 1983–1984) indicates that the regression equation with the above weather parameters is having less predictive value to estimate the trends in larval population and therefore needs a further comprehensive study for the

improvement of the prediction equation by including more weather and environmental factors such as stage of the crop growth, soil condition, sunshine, distribution of rainfall *etc.*

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Entomon, 1988, *Vol.* 13, *No.* 3 & 4, *pp.* 275 *to* 277

BRIEF COMMUNICATION

ON CONTROL OF THE RED SCALE *AONIDIELLA AURANTII* MSKLL. ON ROSE

C. NANDAKUMAR, P. REGHUNATH & K. R. SHEELA
College of Agriculture, Vellayani, Trivandrum, India 695 522

(Received 28 June 1987)

Out of five insecticides evaluated to control the red scele of rose, *Aonidiella aurant* Mskll., carbofuran, monocrotophos (0.05%), dimethoate (0.05%) and phosphamidon (0.05%) were the most effective.

(Key words: rose, red scale, insecticidal control)

The red scale *Aonidiella aurantii* Mskll. (Diaspididae) is a serious pest of rose in Kerala. Parathion, dichlorvos, malathion, dimethoate and malathion, with fish oil-rosin soap have been reported effective against rose scales (BALASUBRAMONIAN *et al.*, 1972). BATRA *et al.* (1968) suggested spraying with 0.1% parathion twice a year to control this pest on rose. The present contribution embodies results of an experiment conducted in 1985 to assess the relative efficacy of some of the common insecticides for control of the pest.

Five insecticide formulations were evaluated (Table 1). A completely randomised design was adopted with each treatment replicated twice. Each treatment consisted of twenty potted plants in total. Pre- and post-treatment counts of the scale insects were taken on marked areas of 10 cm length on each plant. Each plant was given a scrub by swabbing the stem with the respective insecticide solution using a brush. In the treatment with water spray, swabbing was done with water. Swabbing was not done in the control plants. The plants were then given a spray of the respective treatments with a knapsck sprayer. Scrubbing with insecticide was reported to be effective against the scale in citrus by ZUMIGA (1965). Carbofuran granule was incorporated into the soil in the pots. The efficacy of the insecticide was assessed by recording the number of healthy hard reddish scale population 7, 21, 42 and 60 days after application of the different insecticides. The dead scales were light ashy in colour, papery and are retained on the stem. The dead scales flake off when rubbed lightly. The data were subjected to analysis of co-variance.

The results (Table 1) revealed that there was significant reduction in the population of scales due to all the insectidal treatments. On the 7th and 21st days after application, the lowest number of scale insects was observed on monocrotophos treated plants, the plants treated by the other insecticides showing higher numbers.

On the 42nd day, the lowest population was noticed on plants treated with phosphamidon 0.05 per cent and carbofuran which were on par. By the 60th day of insecticide application, carbofuran was the best treatment and significantly

TABLE 1. Effect of different insecticidal treatments on the control of red scale on rose.

Treatments	Mean number of scales on 10 cm length of rose stem after different intervals of application (days)			
	Before the treatment	7	21	42	60
carbofuran 3G 10 g/pot	107.33	40.07 (6.33)	9.18 (3.03)	14.52 (3.81)	48.86 (6.99)
phosphamidon 0.05% E	109.33	12.18 (3.49)	14.06 (3.75)	13.32 (3.69)	103.23 (10.16)
,, 0.025% E	98.67	19.71 (4.44)	16.89 (4.11)	45.56 (6.75)	149.82 (12.24)
dimethoate 0.05% E	105.67	17.64 (4.20)	16.89 (4.11)	23.04 (4.80)	103.02 (10.15)
,, 0.025% E	106.00	22.66 (4.76)	22.56 (4.75)	52.85 (7.27)	157.50 (12.55)
monocrotophos 0.05% E	103.33	8.01 (2.83)	6.55 (2.56)	20.25 (4.5)	98.01 (9.90)
,, 0.025% E	103.0	24.01 (4.90)	16.81 (4.10)	44.62 (6.68)	155.25 (12.46)
quinalphos 0.05% E	101.67	19.27 (4.39)	18.75 (4.33)	43.56 (6.60)	155.25 (12.46)
,, 0.025% E	101.0	45.02 (6.71)	22.85 (4.78)	71.57 (8.46)	178.22 (13.35)
water spray	101.0	110.67 (10.52)	116.86 (10.81)	115.56 (10.75)	207.27 (14.39)
control	108.67	122.10 (11.05)	123.21 (11.10)	116.21 (10.78)	233.48 (15.28)
CD at 5% level		0.755	0.415	0.528	0.705

Figures given in parentheses are are transformed values. G. Granule. E. Emulsion spray.

superior to all the other treatments; monocrotophos 0.05 per cent was the second best.

The conclusion from the results is that carbofuran applied at 10 g per plot of 30 cm × 30 cm size was the best treatment in controlling the red scale, the next best sprays being those of dimethoate and phosphamidon each at concentration of 0.05 per cent.

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STUDIES ON *DIRHINUS HIMALAYANUS* (HYMENOPTERA : CHALCIDIDAE) A PUPAL PARASITOID OF *MUSCA DOMESTICA* (DIPTERA : MUSCIDAE)

R. SRINIVASAN & K. N. PANICKER

Vector Control Research Centre (Indian Council of Medical Research), Pondicherry, India 605 006

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Dirhinus himalayanus, a pupal parasitoid of *Musca domestica* was isolated indigenously by the Vector Control Research Centre, Pondicherry and studies on the longevity, fecundity, host feeding behaviour and stinging behaviour were carried out. Biocontrol efficiency was also determined and maximum rate of fly cnntrol achieved was 95.5% when the parasitoids and hosts were subjected in the ratio 10 : 20.

(Key words: Dirhinus himalayanus, Musca domestica, parasite biology)

INTRODUCTION

Dirhinus himalayanus Westwood (Hymenoptera : Chalcididae), a parasitic hymenopetran was found to parasitize the puparia of filth breeding housefly, *Musca domestica* (Diptera : Muscidae) in nature (GEETHA BAI & SANKARNN, 1977). Though extensive studies were carried out on a few species of *Dirhinus* such at *Dirhinus pachycerus*, *Dirhinus* sp. nr. *inficiens* etc., (SANKARAN *et al.*, 1980) very little is known about the biology and biocontrol efficiency of *D. himalayanus* for its use as a biocontrol agent to control houseflies which is known to be a passive vector of many diseases in man and domestic animals (BERNARD-GREENBURG, 1971). Hence a study was carried out on the biology of this parasitoid in the laboratory and results are presented.

MATERIALS AND METHODS

Parasitic wasps emerged from the puparia of housefly collected from a cattleshed in Pondicherry were cultured and mass multiplied in the laboratory under ambient conditions (28±2°C and RH 60—75%).

Studies were carried out on the oviposition pattern by exposing mated and gravid female parasitoid to puparia of housefly (24 to 48 h old) daily till the parasitoid died. The developmental duration of immatures was studied. Infected puparia were dissected in 2% saline solutian, eggs were mounted in glycerine and observed under microscope, while larvae and pupae were cleared in Sinton's fluid (Phenol, latic acid and chloral hydrate in the ratio of 1 : 1 : 2) and mounted in glycerine for examination. Observations were also made on the fecundity and longevity of the parasitoid. Effect of host age upon parasitism was studied by subjecting freshly emerged mated female parasitoid on the puparia of housefly of different age group viz., 0—24, 24—48, 48—72 and 72—96 h old. Host size preference was studied by exposing puparia of housefly with different size i. e., 6. 5 × 3.0 mm, and 4.0 × 1.5 mm to healthy mated female parasitoids.

To find out host feeding behaviour two sets experiments were made: in one batch the parasitoid was allowed to starve while another batch was fed with 50% honey solution. Later both sets were allowed for host feeding and ovipositing in puparia of housefly.

Host stinging behaviour was studied by allowing parasitoid to drill a hole in puparia at a rate of one parasitiod per pupariam for

one minute and latter brushed away, before they could lay eggs.

Studies on the host parasitoid interaction was carried out by exposing parasitoids and hosts in the ratio of 1:20, 2:20, 3:20, 4:20, 5:20, 10:20 for 10 days. A control was also run concurrently for all sets of experiments, where no parasitoid was exposed to the puparia.

RESULTS AND DISCUSSION

Freshly emerged male and female parasitoids measure 4.0 to 5.0 and 4.0 to 5.5 mm in size respectively and they are sexually mature at emergence. They mate readily on the day of emergence and the duration of mating ranged from 45–122 sec (average 72 sec). A few females started oviposition soon after mating. The duration of oviposition ranged from 3 to 64 mts (av. 30 mts).

The egg was ellipsoidal in shape, whitish in colour and measured 0.7 mm in length and 0.28 mm in breadth. The diameter of the ovipositor (0.05 mm) was smaller than that of egg (0.28 mm) and the egg had been squeezed out slowly through the ovipositor into the puparia. The total number of eggs laid per female per day ranged from 1 to 14 and the total number of eggs laid by a single female varied from 84 to 189 (av. 127.3). The rate of oviposition increased from 1st day, reached a peak on 18th day and decreased gradually thereafter. The pre-oviposition, oviposition and post-oviposition period varied from 1–4, 19–29 and 1–3 days respectively.

The developmental duration of the parasitoid ranged from 29 to 36 days (av. 32.5 days). Males emerged first and were followed by females. The sex ratio of progenies was 1:7.9 (av. of 10 replicates). The incubation period ranged from 12–24 h whereas the developmental duration of larvae and pupae varied from 11–15 (av. 12.2), 10–16 (average: 13.7) days respectively.

Maximum degree of parasitism (75%) was achieved in the age group of 24–48 h old puparia. However the rate of parasitism was 45% in the age group 0–24 and 48–72 h and 15% in 72–96 h old puparia. In the host size preference study parasitoids usually preferred larger puparium (6.5 × 3.0 mm) than the smaller one (4.0 × 1.5 mm). The proportion on the emergence of female progeny was relatively high in the larger puparium than in the smaller one. However mortality of parasitoids was more in the smaller puparia. Perhaps in solitary parasitoids, puparial size influences the longevity, fecundity and survival rate of parasitoids (TAYLOR, 1964). In the host feeding behaviour study, the female devoid of honey was found to feed on the puparia exudate more often than those fed with honey. From the puparia stung by the parasitoids, no housefly emerged indicating that they had killed the pupa by stinging prior to oviposition.

In the host parasitoid interaction study the rate of control of houseflies in different ratio were 50.8%, 62.3%, 71.7%, 78.6%, 83.6% and 95.5% when parasitoids and hosts were subjected in the ratios 1:20, 2:20, 3:20, 4:20, 5:20 and 10:20 respectively, denotes that the increase in parasitoid density increases the rate of control of houseflies.

D. himalayanus has the desired potential for the control of houseflies, due to its high fecundity and longevity. Moreover, it depends only on the puparia of houseflies for propagation and maintenance. Nonhaematophagous habit, high parasitization rate, stinging capacity, ability to survive in various climate and to recycle in cattle shed and poultry farms enhance

its potential for use as a biological agent. However its potency under field condition is to be determined.

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FIELD PARASITISM BY *APANTELES FLAVIPES* CAM. (HYMENOPTERA : BRACONIDAE) ON *CHILO PARTELLUS* SWINH. IN *COIX LACHRYMA-JOBI* L. AND *CHILO AURICILIUS* (DUDGN). IN SUGARCANE IN INDIA

K. RAMACHANDRAN NAIR[1]

C A B International Institute of Biological Control, Post Bag 2484, H. A. Farm P. O. Bangalore, India 560 024

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The graminaceous weed, *Coix lachryma-jobi*, which grows along with sugarcane and in fallow lands, is an important host of the polyphagous stem borer, *Chilo partellus* at Golagokarannath in Uttar Pradesh (India). In November, the borer builds up high populations on *C. lachryma – jobi* and undergoes hibernation in it. *Apanteles flavipes* kills 90.57% to 100% hibernating larvae of *C. partellus* in *C. lachryma-jobi* in three to four months from November to February. While 50% larvae of *Chilo auricilius* present in *C. lachryma - jobi* ate parasitised by *A. flavipes*, it does not contribute significantly to suppress the population of *C. auricilius* in sugarcane, suggesting that sugarcane is not a preferred habitat of *A. flavipes* in India. The studies prove that the Indian strain of *A. flavipes* can drastically reduce the populations of hosts in *C. lachryma-jobi* but not in sugarcane.

(*Key words:* weed, *Coix lachryma, Chilo partellus, host, Apanteles flavipes, Chilo auricilius,* hibernation, parasitisation, sugarcane)

INTRODUCTION

Parasitism by indigenous larval parasitoids of *Chilo* spp. (Lepidoptera : Crambidae) in sugarcane is low or negligible in India. With a view to determining the reasons for this, detailed studies were conducted in some sugarcane growing tracts. Observations made at Motipur in Bihar revealed that wild grasses influenced borer populations in cane, parasitism of borers and consequently the extent of damage to cane (NAGARRATTI & NAIR, 1973). *Apanteles flavipes* Cam. (Hymenoptera : Braconidae) was the only important larval parasitoid of *Chilo* spp. and it parasitised a number of host species occurring on a wide variety of host plants. Its parasitism in cane was low, although the parasitoid was active on borers in other Graminae. When *Chilo partellus* (Swinh.) was not available in maize or sorghum, parasitism by *A. flavipes* on borers in canes was appreciable.

At Golagokarannath in Uttar Pradesh, *Chilo auricilius* (Dudgn.) is the major moth borer pest of sugarcane from September to March, occurring in the maturing and millable canes. The graminaceous weed, *Coix lachryma-jobi* L. is known as a host of *C. partellus* (FLETCHER & GHOSH, 1920). It grows along with sugarcane and in fallow lands. Observations made on the incidence of *C. partellus* in *C. lachryma-jobi* and comparative parasitism by *A. flavipes* on *C. partellus* in *C. lachryma-jobi* and *C. auricilius* in sugarcane from

[1] Present Address: Central Plantation Crops Research Institute, Pacha P. O. Palode, Trivandrum Dist., Kerala, India.

November 1973 to March 1974 are presented.

MATERIALS AND METHODS

The number of *C. lachryma-jobi* shoots present in one ha of fallow land was estimated by counting the shoots in 100 sq m from ten locations selected at random. The percentage infestation by *C. partellus* was calculated by sampling 60 shoots each from ten sites, selected at random. Parasitism by *A. flavipes* on *C. partellus* was also recorded from 300 stubbles of *C. lachryma-jobi*, 8 to 10 cm in length collected randomly from an area of 0.5 ha. All available larvae of *C. auricilius* from *C. lachryma-jobi* and 200 larvae from sugarcane were collected and per cent parasitism by *A. flavipes* was recorded. The samples were collected once in a month from November 1973 to February 1974.

RESULTS

In sugarcane, incidence of *C. auricilius* from October 1973 to February 1974 ranged from 2% (6 per 300 canes) to 90% (270 per 300 canes), maximum being in localities where sugarcane was grown continuously.

C. partellus, the principal borer of maize and sorghum, was abundant in *C. lachryma jobi*. The seeds of *C. lachryma jobi* germinated immediately after the rains in June-July in fallow lands as well as in sugarcane fields, where luxuriant

TABLE 1. Incidence of *C. partellus* in *C. lachryma-jobi* shoots and stubbles and parasitism by *A. flavipes* at Golagokarannath.

No. examined : Shoots—600; Stubbles—300

		No. of shoots infested by *C. partellus*	Per cent infestation	No. of *C. partellus* larvae in infested shoots	No. of *partellus* larvae parasitised by *A. flavipes*	Per cent parasitism
A. In shoots	November 1973	330	55.0	339	159	46.90
	December 1973	118	19.70	119	47	39.50
	January 1974	68	11.3	69	24	34.78
	February 1974	35	5.8	35	3	8.57
	March 1974	Larvae penetrated into soil				
B. In stubbles	November 1973	177	59.0	213	117	54.9
	December 1973	43	16.0	49	35	71.4
	January 1974	2	0.66	2	2	100.0
	February 1974	Nil	-0-	-0-	(Whole population was killed. The area was throughly examined subsequently, but no larvae were found).	

TABLE 2. Estimated population of *C. partellus* in one ha of *C. lachryma-jobi* shoots and reduction of *C. partellus* larvae due to parasitism by *A. flavipes*.

Month	Estimated population of *C. partellus* per ha	Estimated population of *C. partellus* parasitised by *A. flavipes* per ha	Reduction of *C. partellus* per ha	Percentage reduction of *C. partellus* per month
November 1973	4,41,491	2,07,071	—	—
December 1973	1,54,977	61,209	2,86,514 (Nov–Dec)	64.89
January 1974	89,861	31,256	65,116 (Dec–Jan)	42.01
February 1974	45,581	3,907	44,280 (Jan–Feb)	49.27
March 1974	Larvae penetrated into the soil			
	No. of larvae escaped parasitism = 45,581—3,907 = 41,674			
	No. of larvae killed during November to February = 4,41,491—41,674 = 3,99,817, ie. 90.57%			

growths resulted in failure of the crop. The weed attained the height of sugarcane by September—October and it is nutritionally adequate for the normal development of *C. partellus*. Infestation by *C. partellus* was noted in September and some larvae pupated and emerged in October. Heavy oviposition by *C. partellus* occurred in early October.

The mature larvae hibernated from November and adults emerged in june–July. The generation in winter extended for 8 to 9 months. One and occasionally 2 or 3 larvae were observed in the main shoot during October–November. In December when the shoots began to dry up, the larvae were seen between the first and third nodes above the soil. By January when the shoots were completely dry, the larvae were in the lowest node, 3 to 6 cm below the ground level. Several larvae entered the soil in February and from March onwards no larvae were accessible to *A. flavipes* with all larvae having entered into hibernation in the soil.

There were 7814 shoots of *C. lachryma-jobi* in the 100 sq m area examined. Percentage infestation, larval population and parasitism by *A. flavipes* in *C. lachryma-jobi* shoots as well as in the stubbles are presented in Table 1. The population of *C. Partellus* in *C. lachryma-jobi* shoots in one ha, the number of larvae parasitised by *A. flavipes*, the reduction of *C. partellus* larvae per ha due to parasitism and percentage reduction of larval population estimated in each month based on the data given in Table 1, are provided in Table 2. As *C. partellus* was hibernating in larval stage, there was no immigration or emigrationof adults. Moreover, no parasitoid other than *A. flavipes* was found parasitising the hibernating larvae.

C. auricilius larvae in *C. lachryma–jobi* was very scarce. Of the 14 larvae obtained, 7 were parasitised by *A. flavipes*. Parasitism of 200 larvae of *C. auricilius* in sugarcane in November and December 1973 and January and February 1974 was 6.0, 1.5, 7.5 and 5.0% respectively.

DISCUSSION

C. lachryma-jobi is an important host plant of *C. partellus* and supports a large population of the borer. Parasitism by *A. flavipes* ranged from 8.57% to 46.90% on *C. partellus* in *C. lachryma–jobi* shoots and 54.90% to 100% in the stubbles. While 90.57% hibernating larvae of it in *C. lachryma–jobi* shoots were killed by *A. flavipes* in four months (November to February), the whole population of it in the stubbles was killed in three months (November to January). At the same time, there was no significant parasitism of *C. auricilius* in sugarcane. However, 50% larvae (7 / 14) of *C. auricilius* in *C. lachryma–jobi* were parasitised by it, suggesting that sugarcane was not the preferred host plant of *A. flavipes* in India. From earlier studies NAGARKATTI & NAIR (1973) had postulated that *Chilo* larvae in sugarcane are not easily accessible to parasitoids. *A. flavipes* introduced to the western hemisphere from India established itself on the sugarcane borer, *Diatraea saccharalis* (F.) in Barbados (ALAM *et al.* 1971), the USA (CHARPENTIER *et al.*, 1972, FUCHS *et al.*, 1979), Brazil (PEREIRA *et al.* 1977) Colombia, Panama, Venezuela (CIBC, 1979) and Peru (CIBC, 1980). It also established on *Chilo sacchariphagus* (Bojer) in Madagascar (GREATHEAD, 1971). Studies conducted by MOHYUDDIN *et al.* (1981) on host selection by *A. flavipes* revealed the existence of different strains adapted to different graminaceous crops. The factors leading to the adaptation of the Pakistan strain of *A. flavipes*, on *Chilo partellus* in maize to *Diatraea saccharalis* in sugarcane in Trinidad, suggested by MOHYUDDIN *et al.* (1981) may well be applicable for the Indian strain also and this needs to be confirmed by conducting laboratory tests.

Since Indian strain of *A. flavipes* does not contribute towards significant reduction of *Chilo* spp. in sugarcane in India, it would be worthwhile introducing additional strains for possible establishment on stem–borers in sugarcane.

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INFLUENCE OF AGE, SEX AND FEEDING ON THE PROTEASE ACTIVITY OF CERTAIN TISSUES OF FIFTH INSTAR SILKWORM *BOMBYX MORI*

GEETA JADHAV & V. L. KALLAPUR

Department of Studies in Zoology, Karnatak University, Dharwad, India 580 003

(Received 14 November 1987)

Influence of age, sex and feeding on the protease activity in midgut and integumentary tissues of 5th instar *B. mori* was determined. The results indicated that the midgut tissue protease activity significantly increased during active feeding periods upto the 7th day of larval development. However, in the subsequent periods of 8th and 9th day the enzyme activity in the midgut significantly reduced as a result of starvation before they began to spin the cocoons. Sexual dimorphism in the midgut protease was evident in that female showed higher enzyme activity than the male. The increased protease activity in the integument prior to spinning process is believed to provide precursors for silk protein synthesis. The feeding activity of the larvae stimulated protease production in the midgut tissue.

(*Key words:* age, sex, feeding, protease activity, midgut, integument, silkworm, *Bombyx mori*)

INTRODUCTION

The silkworm *B. mori* is an oligophagous insect that feeds mainly on mulberry leaves *(Morus alba)*. The 5th instar larvae show a phenomenal growth rate during the first 6–7 days of their development. The fat body accumulates large quantity of proteins, lipids and glycogen during the development of 5th instar larval stage. These results suggest that the 5th instar larvae digest and utilize efficiently the nutrient reserves of the mulberry leaves. An active protease in the digestive fluid has been reported in the silkworm (HORIE *et al.* 1963; EGUCHI & YOSHITAKE, 1967; HAMANO & MAKAIYAMA, 1970; NISHIDA & HAYASHIYA, 1974; EGUCHI & IWAMOTO, 1976). Protease of the digestive fluid has been separated into three components and their enzymatic properties have been reported (IWAMOTO & EGUCHI, 1978). Most of these studies are confined to the protease of the digestive fluid. It has been suggested that there is a functional differentiation between digestive fluid and midgut tissue, that is molecular proteins are hydrolyzed into peptides in the digestive fluid and into amino acids with peptidases in the midgut tissue (HORIE *et al.*, 1963).

In the present study protease activity of the midgut and integument tissues of 5th instar *B. mori* was examined with reference to age, sex and feeding.

MATERIALS AND METHODS

The laboratory bred bivoltine (NB_{18}) 5th instar silkworm larvae were used as the experimental insects. The rearing technique of larvae was essentially similar to that described by KRISHNASWAMY *et al.* (1978). Male and female 5th instar larave were dissected in the ice-cold *Bombyx* saline (YAMAOKA *et al.*, 1971).

The complete alimentary canal was removed from the larva and was flushed with ice-cold saline three times so as to remove the leaf debris. The midgut was carefully separated from the rest of the alimentary tract and stored over the crushed ice. After the removal of all the organ systems the integument was scraped and made free from the fat body and trachea and used. The tissue was first cut into smaller fragments and then homogenized in an appropriate ice-cold buffer in a 1 ml capacity glass homogenizer with a teflon pestle. During the process of homogenization the glass homogenizer was immersed in crushed ice. The homogenate was centrifuged in a high speed refrigerated centrifuge (4°C) at 8000 *g* for 15 min. The supernatant was collected and used as the crude enzyme source in all the experiments.

Protease activity was determined according BIRK *et al.* (1962) with a slight modification as outlined by ISHAAYA *et al.* (1971). The incubation mixture consisted of 400 μl of 1 per cent casein solution (vitamin free); 200μl of enzyme source (120 μg protein); 200 μl of 0.2M tris HCl buffer (pH 8.5). The incubation was carried out at 30°C for 60 min with constant shaking. After 60 min, the enzyme activity was terminated by adding 2.4 ml of 2 per cent trichloroacetic acid. The content of the tube was centrifuged at 8000 *g*. The absorbance of the supernatant was recorded at 280 nm agaist a blank in which the enzyme extract was substituted by demineralized water. Tyrosine was used as the reference standard. A duplicate sample whose enzyme source was denatured before the addition of the substrate was also run as the control side by side with the original sample. The enzyme activity was expressed in terms of specific activity (μg tyrosine equivalent liberated/mg protein/min). The protein content of the enzyme source was determined according to the method of LOWRY *et al.* (1951). The enzyme activity expressed was the maximum obtainable under the conditions mentioned in this investigation.

RESULTS AND DISCUSSION

The activity of protease of the midgut tissue of 5th instar *B. mori* progressively increased as the larva advanced in age upto the 7th day in both the sexes (Table 1). The leaf consumption of 5th instar *B. mori* amounts to more than 75 per cent of the total for the whole larval

TABLE 1. Protease activity in the midgut tissue of 5th instar *B. mori* with reference to age and sex.

Age (day)		specific activity (μg tyrosine liberated/mg protein/min) female	male	*P* value
1	(3)	0.28 ± 0.03^a	0.27 ± 0.07	NS
2	(3)	0.38 ± 0.07^b	0.27 ± 0.03^a	< 0.005
3	(3)	0.86 ± 0.03^c	0.43 ± 0.04^b	< 0.001
5	(3)	1.19 ± 0.03^d	1.13 ± 0.12^e	< 0.5
7	(3)	1.52 ± 0.03^e	1.50 ± 0.06^e	NS
8	(3)	0.39 ± 0.01^f	0.64 ± 0.04^d	< 0.001
9	(3)	0.23 ± 0.08^g	0.30 ± 0.02^e	< 0.002

The results are mean $\pm$ SE of five experiments. n = 3. The different superscripts indicate the results that are significant ($p < 0.01$). NS, not signaificant. Number of insects used is indicated in parenthesis.

TABLE 2. Protease activity in the integument of the 5th instar *B. mori* with reference to age and sex.

Age (day)		specific activity (μg tyrosine liberated / mg protein / min) female	male	p value
1	(4)	1.97 ± 0.06[a]	2.02 ± 0.07[a]	NS
2	(4)	1.90 ± 0.06[a]	1.86 ± 0.08[a]	NS
3	(4)	1.80 ± 0.09[b]	1.90 ± 0.06[a]	NS
5	(4)	2.5 ± 0.02[c]	2.15 ± 0.02[b]	< 0.001
7	(3)	2.68 ± 0.01[d]	2.45 ± 0.01[c]	< 0.001
8	(4)	2.92 ± 0.04[e]	2.80 ± 0.03[d]	< 0.05
9	(4)	0.56 ± 0.05	0.40 ± 0.85[e]	< 0.05

The results indicate mean ± SE of five determinations. Number of insects used is indicated in parenthesis. The different superscript indicate the results that are significant ($p<0.01$) NS, not significant.

instars. This high intake of food by the 5th instar larva is to accumulate sufficient energy resources to support its metabolism during non-feeding pupal-adult development. The leaf proteins are first hydrolyzed to peptides by the digestive fluid protease(s) and finally into amino acids by midgut tissue protease. Sexual dimorphism in respect of midgut protease was evident in that the female larvae showed significantly higher enzyme level than that of the male. The protein requirement of the female is always higher than male on account of egg production. The protease activity in the midgut tissue was significantly reduced on 8th and 9th day of larval development (Table 1). This appeared to be due to the starvation of the larvae. Normally the *B. mori* larvae stop feeding 48h before they start spinning the cocoons.

The protease activity in the integument with reference to age indicated that the enzyme remained almost at the same level during the first three days of development (Table 2). The enzyme activity increased thereafter upto 8th day of larval age. It has been proposed that proteins from the disintegrating integument are used for the silk protein synthesis (KOGA, 1978). The increased protease activity in the integument before the start of spinning is to hydrolyze integumentary proteins to release the precursors for the silk protein synthesis by the silk gland.

It has been suggested that the midgut enzyme production and secretion varies in insect. In continuous feeding insects the enzyme production and secretion did not vary while in discontinuous feeders enzymes were produced on demand (APPLEBAUM, 1985). In blood sucking insects the production of protease is dependent on the size of the blood meal (DOWNE *et al.*, 1963; GOODING, 1972). While

TABLE 3. Protease activity in the midgut tissue of five day old 5th instar, *B. mori* in response to feeding activity.

Time interval in hour		specific activity (μg tyrosine liberated/mg protein / min)	*p* value
1	(4)	1.16 ± 0.1	
2	(4)	2.2 ± 0.13[a]	< 0.025
3	(4)	3.6 ± 0.17[b]	< 0.001
4	(4)	2.9 ± 0.1[c]	< 0.02
6	(4)	1.02 ± 0.08[c]	NS

The results indicate mean ± SEM of five determinations. The different superscript indicate the results that are siginificantly different. Figure in parenthesis indicate number of insects used.

working with protease activity in the larvae of *Spodoptera littoralis*, ISHAAYA *et al.* (1971) have shown that certain protein factors present in the food can stimulate digestive enzymes probably through a hormonal mechanism. The 5th instar larvae of *B. mori* are constantly fed and may be regarded as continuous feeders. The midgut protease activity significantly increased only 2 h after the feeding commensed. The enzyme activity significantly depleted after 4 hours (Table 3). The tissue protease may reasonably be regarded as an index of the rate of synthesis of enzyme in secretory cells. In the light of the present observations, it is believed that the feeding stimulates the protease production in the midgut tissue of 5th instar *B. mori*. However, further research is required to identify whether or not the factors responsible for the midgut tissue protease production originates from its food plant.

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VERTICAL DISTRIBUTION OF MOSQUITOES IN MANIPUR

K. B. RAJPUT[1] & T. K. SINGH

Department of Life Sciences, Manipur University, Manipur, India 795 003

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Vertical distribution of 90 mosquito species under 10 genera from four altitudinal strata viz., stratum A: 150—600 m, stratum B: 601—1200 m, stratum C: 1201—1800 m and stratum D: above 1800 m, in the state of Manipur were recorded. About 76 species (83.52%) were recorded from stratum B, while the descending numbers i. e., 33 (36.26%), 25 (27.47%), and 18 (19.78%) were collected from stratum A, C and D respectively. The congenial climatic conditions prevalent, breeding habitats and high density of preferred hosts are the probable causes for this prevalence in stratum B.

(Key words: vertical distribution, mosquitoes, Manipur)

INTRODUCTION

The extensive survey for mosquito fauna from the state of Manipur during September 1983 to October 1985 revealed the presence of more than 90 species in the state which includes many important vectors for mosquito borne diseases. The state of Manipur is a part of Assam–Aracan hill range where variation in altitude is remarkable. This altitude variation in the state is responsible for prevalent varied physiography which finally influences the distribution of mosquito fauna. With this idea, systematic survey of mosquitoes was undertaken and this has yielded interesting results with respect to the vertical distributional pattern of mosquito species.

Study area: The state of Manipur, area under study, lies at the north eastern border of the country between 23.83° and 25.68° N latitude and 93.05° and 94.78° E longitude. The state has an area of about 22,327 sq km and is bounded on morth by Nagaland, on south by the Lushai hills and Burma, on the west by Cachar district of Assam and on the east by Burma. Topographically the state has a centrally situated valley (area 1,765 sq km) surrounded by north-to-south running parallel hill ranges. About 20,736 sq km area of the state is covered by the hills. The state shows altitudinal variation from 150 to 3,050 metres. With regard to the riverine system of Manipur, the state is drained by Barak and its tributaries at north to south-west region; Imphal, Iril, Thoubal and Nambol at Western region; Khuga and Chakpi at southern region; and by Yu and its tributaries at south east Indo–Burma Border. The Barak is the biggest river of the state. The state also has a fresh water lake largest in North–East India having an area of 60 sq km. The Manipur hillocks are covered with mixed deciduous forest.

The state enjoys salubrious climate with well marked winter and overlapping summer and rainy seasons. The winter season commences from November to

[1] Present address: Regional Tasar Research Station, Mantripukhri, Imphal, Manipur, India 795 002.

February, and summer from April to September. The summer season is the season of rain also. The months of March and October are the transition between winter – summer and summer – winter respectively. The December and January are the coldest months of the state while appreciable temperature remains during the month of June. The state admits a temperature range of 0°C to 38.5°C and relative humidity from 20 to 100%.

Though the rainy season commences from April to June. July and August receives the maximum precipitation. Due to hilly nature and varied elevations, place to place rainfall variations, have been characterised for the state. But the hilly region receives more rain than the valley. The average annual rainfall for the state is about 2077.7 mm (1984).

MATERIALS AND METHODS

The state of Manipur which shows the altitudinal variation up to 3,050 meters was divided into 4 altitudinal strata viz., stratum A : 150—600 m, stratum B : 601—1,200 m, stratum C : 1,201–1,800 m and stratum D : over 1,800 m. Mosquito collection at regular monthly intervals were done from two fixed localities from each of the alitudinal stratum. However, in addition to the fixed localities collections from other localities have been also considered for the appropriate strata according to altitude. The mosquitoes were collected as adults by aspirator tube and torch-light from different habits and by different methods (WHO, 1975). The immatures collected with enamel dipper were reared in the laboratory upto the adult stage on artificial diet.

The adults collected from field or reared in the laboratoy from field samples were identified with the help og BARRAUD (1934), CHRISTOPHERS (1933), HARRISON (1980), RAO (1984) and SIRIVANAKARN (1976). Besides some other papers were also consulted. The taxonomic nomenclature were followed from KNIGHT & STONE (1977).

RESULTS AND DISCUSSION

During the study total 90 species of mosquitoes under 2 subfamilies and 10 genera viz., *Anopheles*, *Aedes*, *Armigeres*, *Heizmannia*, *Culex*, *Mimoyia*, *Coquillettidia*, *Mansoia*, *Tripteroides* and *Uranotaenia* were collected. In general, the stratum B shows highest number of species followed by stratum A harbouring 33 species. The stratum C shows comparatively fever number of specices (Table 1). The trend of the relative abundance of mosquito-species at different altitudinal strata has revealed that preferred stratum exists between 601m and 1200m and abundance of the species and diversity decrease both below and above this stratum. This is probably due to the availability of favourite breeding places, congenial climatic factors and availability of preferred host. This stratum mainly comprises most part of the Imphal valley and some hilly regions of the state. The stratum B, i. e., area between 601–1200 m offers various type of breeding places like ponds, paddy fields, lakes, drains, discarded domestic containers, streams, nullah etc. The congenial temperature for mosquito life and eomparatively denser population of human and bovine hosts makes it a favourite area for their multiplication. The similar pattern of vertical distribution was reported for aphids also in the state of manipur (RAYCHAUDHURY *et al.*, 1979) and in Darjeeling district of West Bengal and Sikkim (GHOSH & RAYCHAUDHURI, 1977).

By extending the range of altitudinal strata it has been observed that area from base (150 m) up to 1,200 m contains about 89.3 per cent of species, while the comparable area located between 1,201 and 2,400 contains about 37.4 per cent of the species found in the whole area under consideration. Likewise, when the area is increased upto 1,800 m from base, about 91.0 per cent of the species could be found and when

TABLE 1

S. no.	species	stratum A	B	C	D
1	*Anopheles (Anopheles) barbirostris* Van der Wulp, 1884	—	+	—	—
2	*An. (Ano.) crofardi* Red, 1953	—	—	+	+
3	*An. (Ano.) gigas* Giles, 1901	—	—	—	+
4	*An. (Ano.) lindesayi* Giles, 1900	—	+	—	—
5	*An. (Ano. nigerrimus* Giles, 1900	+	+	+	—
6	*An. (Ano.) peditaeniatus* Leicester, 1908	—	+	—	—
7	*An. (Ano.) sinensis* Wiedemann, 1828	—	+	—	+
8	*An. (Cellia) annularis* Van der Wulp, 1884	—	+	—	—
9	*An. (Cel.) jeyporiensis* var. *candidensis* Koidzumi, 1924	—	+	—	—
10	*An. (Cel.) kochi* Doenitz, 1901	+	+	—	—
11	*An. (Cel.) maculatus* Theobald, 1901	—	+	+	—
12	*An. (Cel.) maculatus* var. *willmorei* James, 1903	—	+	+	+
13	*An. (Cel.) minimus* Theobald, 1901	+	+	—	—
14	*An. (Cel.) philippinensis* Ludlow, 1902	—	+	—	—
15	*An. (Cel.) splendidus* Koidzumi, 1920	—	+	—	—
16	*An. (Cel.) subpictus* Grassi, 1889	—	+	—	—
17	*An. (Cel.) tessellatus* Theobald, 1901	—	+	—	—
18	*An. (Cel.) vagus* Doenitz, 1902	+	+	—	+
19	*Aedes (Aedimorphus) alboscutellatus* Theobald, 1905	—	+	—	—
20	*Ae. (Adm.) caecus* The bald, 1901	+	+	+	—
21	*Ae. (Adm.) vexens* Meigen, 1830	—	+	+	—
22	*Ae. (Diceromyia) iyengari* Edwards, 1923	+	—	—	—
23	*Ae. (Finlaya) chrysoleineatus* Theobald, 1907	—	+	—	—
24	*Ae. (Fin.) elsiae* Barraud, 1923	—	+	+	—
25	*Ae. (Fin.) formosensis* Yamada, 1921	+	+	—	—
26	*Ae. (Fin.) niveus* group	—	+	+	+
27	*Ae. (Fin.) shortti* Barraud	+	—	+	—
28	*Ae. (Neomelaniconion) lineatopennis* Ludlow, 1905	—	+	—	—
29	*Ae. (Stegomyia) aegypti* Linnaeus, 1762	—	+	—	—
30	*Ae. (Stg.) albopictus* Skuse, 1894	—	+	+	+
31	*Ae. (Stg.) annandalei* Theobald, 1910	+	+	—	—
32	*Ae. (Stg.) craggi* Barraud, 1923	+	—	—	—
33	*Ae. (Stg.) gardnerii* var. *imitator* Leicester, 1908	—	+	—	—

Table 1 (Contd.)

34	*Ae. (Stg.) mediopunctatus* Barraud, 1905	–	+	–	–
35	*Ae. (Stg.) pseudalbopictus* Borel, 1928	–	–	+	–
36	*Ae. (Verrallina) andamanensis* Edwards, 1922	–	+	–	–
37	*Ae. (Ver.) vallistris* Barraud, 1928	–	+	–	–
38	*Armigeres (Armigeres) durhami* Edwards, 1917	+	–	–	–
39	*Ar. (Arm.) subalbatus* Coquillett, 1898	+	+	+	–
40	*Ar. (Arm.) theobaldi* Barraud, 1934	+	–	–	–
41	*Ar. (Leicesteria) annulitarsis* Leicester, 1908	–	+	–	–
42	*Ar. (Lei.) dentatus* Barraud, 1927	–	+	–	–
43	*Ar. (Lei.) digitatus* Edwards, 1914	–	+	–	–
44	*Ar. (Lei.) flavus* Leicester, 1908	+	+	–	–
45	*Ar. (Lei.) inchoatus* Barraud, 1927	–	+	–	–
46	*Ar. (Lei.) longipalpus* Leicester, 1904	–	+	+	–
47	*Ar. (Lei.) magnus* Theobald, 1908	–	+	–	–
48	*Ar. (Lei.) omissus* Edwards, 1914	–	+	–	–
49	*Heizmannia (Heizmannia) complex* Theobald, 1910	+	+	+	+
50	*Culex (Culex) bitaeniorhynchus* Giles, 1901	+	+	+	–
51	*Cx. (Cux.) edwardsi* Barraud, 1923	–	+	–	–
52	*Cx. (Cux.) epidesmus* Theobald, 1910	+	+	–	–
53	*Cx. (Cux.) fuscocephala* Theobald, 1907	+	+	–	+
54	*Cx. (Cux.) gelidus* Theobald 1901	+	+	+	–
55	*Cx. (Cux.) infula* Theobald, 1901	–	+	–	–
56	*Cx. (Cux.) mimulus* Edwards, 1915	+	+	+	–
57	*Cx. (Cux.) pseudovishnui* Colless, 1957	+	+	+	+
58	*Cx. (Cux.) quinquefasciatus* Say, 1823	+	+	+	–
59	*Cx. (Cux.) sinensis* Theobald, 1903	+	+	+	–
60	*Cx. (Cux.) theleri* Theobald, 1903	–	–	+	+
61	*Cx. (Cux.) tritaeniorhynchus* Giles, 1901	+	+	+	+
62	*Cx. (Cux.) vishnui* Theobald, 1901	–	+	–	–
63	*Cx. (Cux.) whitmorei* Giles, 1904	+	+	+	–
64	*Cx. (Culiciamyia) harrisoni* Sirivanakaran 1977	–	–	–	+
65	*Cx. (Cui.) nigropunctatus* Edwards, 1926	–	+	–	–
66	*Cx. (Cui.) pallidothorax* Theobald, 1905	–	+	–	+
67	*Cx. (Cui.) viridiventer* Giles, 1901	–	–	–	+
68	*Cx. (Eumelanomyia) brevipalpis* Giles, 1902	+	+	–	–
69	*Cx. (Cum.) malayi* Leicester, 1908	+	+	–	–

Table 1 (Contd.)

70	*Cx. (Lophoceraomyia) bengalensis* Barraud, 1934	–	+	–	–
71	*Cx.* (*Lop.*) *cinctellus* Edwards, 1922	–	+	–	–
72	*Cx.* (*Lop.*) *infantulus* Edwards, 1922	+	–	–	–
73	*Cx.* (*Lop.*) *minor* Leicester, 1908	–	–	–	+
74	*Cx.* (*Lop.*) *rubithoracic* Leicester, 1908	–	+	–	
75	*Cx. (Lutzia) fuscanus* Wiedemann, 1820	–	+	–	–
76	*Cx. (Lut) halifaxi* Theobald, 1903	+	+	–	+
77	*Mimomyia (Etroleptiomyia) luzonensis* Ludlow, 1905	–	+	–	–
78	*Mi . (Mimomia) chamberlaini* Ludlow, 1904	–	+	–	–
79	*Mi. (Mim.) hybrida* Leicester, 1908	+	+	–	–
80	*Coquillettidia (Coquillettidia) crassipes* Van der Wulp, 1881	+	+	+	–
81	*Mansonia (Mansonoides) annulifera* Theobald, 1901	–	+	–	–
82	*Ma. (Man.) indiana* Edwards, 1930	–	+	–	–
83	*Ma. (Man.) uniformis* Theobald, 1901	+	+	+	–
84	*Tripteroides* (*Tripteroides*) *indicus* Barraud, 1929	–	+	–	–
85	*Uranotaenia* (*Pseudoficalbia*) *bicolor* Leicester, 1908	–	+	–	–
86	*Ur.* (*Pfc.*) *bimaculata* Leicester, 1908	–	–	–	+
87	*Ur.* (*Pfc.*) *recondita* Edwards, 1922	–	+	–	–
88	*Ur.* (*Uranotaenia*) *campestris* Leicester, 1908	+	+	–	–
89	*Ur.* (*Ura.*) *edwardsi* Barraud, 1926	–	+	–	–
90	*Ur.* (*Ura.*) *macfarlanei* Edwads, 1914	–	+	–	–

it is increased from the highest level (i. e., 2,400 m) down to 601 m, about 93.4 per cent of the species of the total number of the same, in the area could be found. This indicates that area between 601–1800 m are favourable for the mosquitoes. It is revealed by the fact that even if the bottom stratum ie., upto 600 m, or top stratum ie., the area between 1,801 and 2,400 m, is excluded more or less the the recovery percentage of the specics remains the same.

The vertical distribution of these mosquitoes is discussed below at the generic level.

Anopheles: The maximum number of the species recorded under this genus were collected from the stratum B. Strata A and C have shown an equal number, while it was slightly more in stratum D. The high altitude distribution of *Anophele-* (*Anopheles*) *gigas* and *An.* (*Cellia*) *maculs atus* var. *willmorei* are in agreement with the findings of CHRISTOPHERS (1933). *An.* (*Ano.*) *sinensis* which has a wide distribution in Palearctic region extends its limits to this state and is prevalent in stratum D especially at eastern Indo–Burma border. It is noteworthy to mention that *An. (Cel.) minimus* which are important vectors of malaria in the adjoining states are also

present in stratum A. *An. (Cel.) jeyporiensis* which is well known malaria vector in some forested area of the country restricts its distribution in stratum B only.

Aedes : Like the genus *Anopheles*, genus *Aedes* also shows the maximum number of species present in stratum B. The descending number of the species were recorded from strata C, A and D (Table 1.) The prevalence of some bamboo or tree hole breeders e. g., *Aedes (Finlaya) niveus* group, *Ae. (Stegomyia) albopictus*, *Ae. (Stg.) annandalei*, *Ae. (Stg.) mediopunctatus* in stratum B, is due to the prevalency of bamboo forest in this stratum.

Armigeres : Out of 11 recorded species from the state six species viz., *Armigeres (Leicesteria) annuiltarsis*, *Ar. (Lei.) dentatus*, *Ar. (Lei.) digitatus*, *Ar.(Lei.) inchoatus*, *Ar. (Lei.) magnus* and *Ar. (Lei.) omissus* restricts their distribution in stratum B, while *Ar. (Lei.) longipalpis* and *Ar. (Lei.) falvus* extends its limit to stratum C and stratum A respectively. *Ar. (Armigeres) durhami* and *Ar. (Arm.) theobaldi* were only found in stratum A near southern Indo–Burma border. *Ar. (Arm.) subalbatus* extends its range of distribution in strata A, B and C probably due to its capability to breed in different type of habitats e g., discarded domestic containers, discarded tar barrels, discarded motor tyres etc in vally and in tree holes and bamboo stumps in forested hilly region.

Heizmannia : A single species of the genus ie., *Heizmannia (Heizmannia) complex* was collected from the all examined strata. The species seems to be more habitat-bound than altitude range.

Culex : Members of this genus form the bulk of the mosquito fauna in the state and out of 27 species 22 were encountered in the stratum B followed by stratum A. Total 9 species were found in each of the strata C and D. In addition to record of some common mosquito-species belonging to genus *Culex* the present study also confirms the earlier findings of MALHOTRA *et al.* (1983) at the altititude above 1,800. The earlier high altitude distribution of *Culex (Culex) theleri* from western Himalayan region and from a high altitude locality of the state Ukhrul (2,000 m) by BARRUAD (1934) was found again positive for this species. The first record of *Cx. (Culiciomyia) harrisoni* from the stratum D in the country is in agreement with the earlier and only findings of SIRIVANAKARN (1977) from Thailand.

Mimomyia: Except *Mimomyia (Mimomyla) hybrida* which extends its distribution in stratum A also, the other two specses ie. *Mi. (Etroleptomyia) luzonensis* and *Mi. (Mim.) chamberlaini* are restricted to stratum B only. The distribution of water hyacinths which serves as source of food, oxygen supply and provides support during the larval period.

Coquillettidia : This genus is represented by a single species ie., *Coquillettidia (Coquillettidia) crassipes* in the state, which has its range of distribution in strata A, B & C.

Mansonia : Except the most common species *Mansonia (Mansonoides) uniformis* which was recorded from strata A, B & C the other two species ie., *Ma. (Mand.) annulifera* and *Ma. (Mand) indiana* are restricted to the stratum B only. Like the breeding pattern and distribution of *Mimomyia* the breeding and distribution of *Mansonoides* also seems to be related with water hyacinths which are prevalent in stratum B.

Tripteroides: This genus is represented by a single species *Tripteroides (Tripteroides) indicus* which restricts its limit to stratum B only.

Uranotaenia: Except *Uranotaenia (Uranotaenia) campestris* which extends its range in stratum A, most of the other species are prevalent in stratum B *Ur. (pseudoficalbia) bimaculata* are the only species which limits its distribution in stratum D in the state.

Aedes (Stg.) aegypti (vector of dengue fever); *Culex (Cux.) quinquefasciatus* and *Mansonoides* (vectors of filaria); *Culex (Cux.) tritaeniorhynchus*, *Cx.* "*vishnui*" group and *Cx. (Cux.) bitaeniorhynchus* (vectors of Japanese encephalitis); *Anopheles (Cellia) jeyporiensis* var. *candidensis* and *An. (Cel.) minimus* (vectors of malaria) which are vectors of mosquito borne diseases in the country are also present in stratum B of the state. As this stratum B also harbours more than 65% of the total human population of the state increases the possibility of man mosquito contact causing spread of these mosquito-borne diseases.

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INFLUENCE OF SUBSTRATES ON THE INFECTIVITY OF MILKY DISEASE TO *HOLOTRICHIA SERRATA* F.

A. SUBBA RAO[1] & G. K. VEERESH

University of Agricultural Sciences, G. K. V. K., Bangalore, India 560 065

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Studies on the influence of organic manures on the incidence of the disease revealed more incidence in cattle manure treated soil (45.0%) followed by poultry manure (36.67%), horse manare (28.33%). sheep manure and compost (21.67%), pig manure (18.33%) and urea along with spore suspension (11.67%) for all the larval instars of *H. serrata*. Among the three larval instarts tested second instar grubs were comparatively more vulnerable to the disease infection in the organic manure treated soils.

(Key words: Bacillus popilliae Dutky, spores, infectivity. substrate manures, *Holotrichia serrata* Fab)

INTRODUCTION

It is known that grubs of *Holotrichia* can survive without roots or underground stems in the first and second instar, but they need some live plant material for completing their life cycle (GUPTA *et al.*, 1966; VEERESH, 1977). Therefore, it was intended to know whether mixing the pathogen *Bacillus popilliae* in different organic manures had any effect on the infectivity to grubs.

MATERIALS AND METHODS

To know the effect of various manures as substrates on the disease incidence for all the three instars an experiment was laid out in pots (5 grubs/pot) in a factorial randomized block design. Manure from sheep, pig, horse, poultry, cattle, compost and urea were used as substrates. All these were applied to the soil at the rate of 25 tonnes/ha and urea was applied at 125 kg N/ha.

Four kilograms of sterilized soil along with manure were added to each earthen pot measuring 20 × 20 × 12.5 cm. The experiment was replicated four times. Soil with no manure served as check. The spores *B. popilliae* were inoculated to the soil so as to get a final concentration of 1×10^9 spores per gram of soil. The effectiveness of manures as carriers of pathogen was studied for all the three instars of *H. serrata*. Optimum moisture was maintained by adding water periodically. Treated pots were left as such, for a period of 10—15 days with no addition of food, so as to allow the grubs to consume the substrates along with the spores. Potato pieces were supplied as food as and when needed. The data on the disease development were recorded at weekly intervals.

RESULTS AND DISCUSSION

The influence of organic manures on the percentage infectivity of milky disease to three larval instars of *H. serrata* are presented in Table 1.

From the Table, it is observed that there was a significant difference between substrates used as carriers of spores of *B. popilliae*. Maximum percentage of diseased first instar larvae were recorded in

[1] Present address: Assistant Professor, Dept. of Entomology, Agricultural College, Bapatla 522 101.

TABLE 1. Influence of substrates on the infectivity of milky disease to *Holotrichia serrata*.

Treatments	Ist instar		II instar		III inssar		general mean for treat-ments	mean per cent grubs infected
	mean for treat-ments	per cent grubs infected	mean fof treat-ments	per cent grubs infected	mean for treat-ments	per cent grubs infected		
Sheep manure	(0.185)	15.00	(0.854)	30.00	(0.811)	20.00	(0.817)	21.67
Pig manure	(0.785)	15.00	(0.837)	25.00	(0.785)	15 00	(0.802)	18.33
Compost	(0.837)	15.00	(0.855)	30.00	(0.811)	20.00	(0.817)	21.67
Horse manure	(0.837)	25.00	(0.880)	35.00	(0.837)	25.00	(0.851)	28.33
Poultry manure	(0.880)	35 00	(0.906)	40.00	(0.880)	35.00	(0.889)	36.67
Cattle manure	(0.889)	40.00	(0.971)	60.00	(0.872)	35.00	(0.911)	45.00
Urea	(0.733)	5.00	(0.785)	15.00	(0.785)	15.00	(0.768)	11.67
Without manure	(0.707)	0.00	(0.707)	0.00	(0.707)	0.00	(0.707)	0.00

Source	SEm	C D at 5%
1. Instars	(0.022)	N S
2. Manures	(0.036)	(0 071)
3. Instar × manures	(0.062)	N S
4. Observation	(0.029)	(0.056)
5. Instar × observations	(0.049)	N S

Figures in parenthesis are $\sqrt{X \pm 0.5}$ transformed.

cattle manure (40.0%), poultry manure (35.0%) and horse manure (25.0%).

For the second instar also there was a significant difference between the substrates tried. All the treatments except urea mixed with spore suspension gave higher disease incidence and were found to be on par with each other.

For the third instar no significant difference could be obtained between substrates tried for disease development.

To find out the various interactions on all the three instars, the results were pooled and further analysed in a factorial randomized design using instars as main factor and substrates (manures) and time of observation as sub factors. No significant difference could be obtained on disease incidence between the three larval instars of *H. serrata*. All the substrates other than urea were significantly superior over control. Among these cattle and poultry manures were superior over others (with 45.0% and 36.67% grubs infected respectively) followed by horse manure (28.33%). But sheep manure, pig manure, compost and horse manure were all at par with each other.

Among the days of observation in all three instars more per cent of diseased grubs were recorded on 14th day. The interactions between periods and manures was found to be significant. Cattle manure gave maximum disease incidence on 14th day when compared to other substrates.

The interactions between larval instars and observation, larval instars and substrates were found to be non-significant.

In general, all organic manures have given significant increase in the infection of pathogen to the grubs. It is evident from the above results that organic manures play a major role and the soils having more organic matter are likely to have better infectivity than soil with less organic matter. Although reports of influence of cattle manure has been established in the infectivity of fungal pathogens to *H. serrata* (JAYARAMAIAH, 1901) there are no similar reports of influence of these manures on the infectivity of *B. popilliae* on the grubs. The reason for the better infectivity of the pathogen through organic matter might be due to intake of more spores through organic matter as food by the grub.

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STUDIES ON SUPERPARASITISM IN *EUCELATORIA BRYANI* SABROSKY (DIPTERA : TACHINIDAE), A LARVAL PARASITOID OF *HELIOTHIS* SPP.[1]

SHEKHARAPPA, K. JAIRAO & S. LINGAPPA

Department of Entomology, University of Agriculture Sciences, Darwad, India

(Received 12 December 1987)

Superparasitism is most common in *Eucelatoria bryani* Sabrosky, a tachinid parasitoid of *Heliothis* spp. Studies on one, two, three and four time parasitisation showed that heavily parasitised host resulted in decreased number of puparia per host larvae, pupal weight, adult emergence and adult longevity.

(Key words : Eucelatoria bryani, larval tachinid parasitoid, superparasitism, *Heliothis* spp.)

Eucelatoria bryani Sabrosky is a promising tachinid larval parasitoid of *Heliothis* spp. in Arizona and Western Texas (U S A). In India, although several tachinids have been recorded on *Heliothis armigera* (Hubner), no technique for their large scale multiplication is available for field trials. *E. bryani* gives higher parasitism on *H. armigera* and can be multiplied on this host easily in the laboratory. Superparasitism being very common in this tachinid, an attempt was made to study its effect on the production of puparia, puparial weight, adult emergence and longevity and the results have been presented in this contribution.

H. armigera was reared in the laboratory on tender okra fruits. Five host larvae of fourth instar were taken and exposed for parasitisation for different number of times viz., one (T_1), two (T_2), three (T_3) and four (T_4) larvipositions. Each treatment was replicated four times. The parasitised larvae were kept individually in a specimen tube (7.5 × 2.5 cm) with pieces of tender okra fruit as food. Observations on the number of puparia recovered from each larva, puparial weight, adult emergence and adult longevity were recorded.

Minimum number (1.50) of puparia per host were recorded in the treatment T_4 where larva was parasitised four times, whereas it was maximum (9.88) in treatment T_2 with twice parasitisation (Table 1). The number of pupae per host larva increased from treatment T_1 (4.35) to T_2 (9.88). Pupal weight was highest (26.30 mg) in treatment 1 and was lowest (3.125 mg) in treatment 4 suggesting that the pupal weight decreased as the number of larviposition increased. Maximum adult emergence (87.50 per cent) was noticed in the pupae reared from the host larva parasitised once. Minimum emergence (15.83 per cent) was observed in the treatment with four time parasitisation. Adult emergence decreased significantly

[1] Part of M. Sc. (Agri.) thesis submitted by the first author to the University of Agricultural Sciences, Dharwad.

TABLE 1. Effect of superparasitism on production of puparia, pupal weight, adult emergence and adult longevity of *Eucelatoria bryani* Sabrosky.

Host larviposition (No.)	pupapria/ host larva	pupal weight (mg)	adult emergence (%)	female longevity**
1. (T_1)	4.35	26.30	69.53* (87.5)	5.48 (29.5)
2. (T_2)	9.88	11.95	60.11 (75.00)	4.68 (21.38)
3. (T_3)	3.19	5.25	37.66 (37.50)	4.14 (16.63)
4. (T_4)	1.50	3.125	28.99 (15.83)	1.8 (1.5)
S Em±	0.29	0.24	2.50	0.23
C D at 5%	0.90	0.74	7.70	0.71

* Arc sine transformed values. **Square root transformed values. Figures in bracket are original values.

when the host was parasitised more than once.

ZISER *et al.* (1977) also reported decreased adult emergence in *Eucelatoria* sp. as the host became more heavily parasitised. They also reported that average puparial weight of *Eucelatoria* sp. decreased from 27.2 to 9.2 mg as the density of larva per host *(H virescens)* increased.

Adult longevity was maximum (29.5 days) in the case of once parasitised host whereas it was minimum (1.5 days) in the case of four time parasitised larva. These results are in agreement with SANKARAN & NAGARAJA (1979) who also obtained similar results with *Eacelatoria* sp. nr. *armigera* Coq. when reared on *H. armigera*.

From the above studies it is observed that although more puparia are reared by two time parasitisation, for building up a healthy and strong culture, once parasitisation is advantageous since maximum adult emergence and longevity was noticed in this treatment.

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BRIEF COMMUNICATION

A MERIDIC DIET FOR RICE LEAF FOLDER, *CNAPHALOCROCIS MEDINALIS* (GUENEE)

K. DAKSHAYANI J. S. BENTUR & M. B. KALODE
Directorate of Rice Research, Hyderabad, India 500 030

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Attempts were made to rear rice leaf folder *Cnaphalocrocis medinalis* larvae on artificial diet. Modified *Chilo polychrysa* diet was found to be the most suitable. As many as 37% of neonate leaf folder larvae completed development on this diet.

(Key words: artificial diet, *Cnaphalocrocis medinalis*)

INTRODUCTION

The rice leaf folder, *C. medinalis* is an important pest in almost all the rice growing states of India. Severe infestations leading to considerable yield losses are being reported frequently. This insect is being reared in the greenhouse on host plant at the All India-Directorate of Rice Research, Hyderabad, for various experimental purposes since 1979. Rearing on artificial diets would greatly facilitate mass rearing of the pest throughout the year. As no information is available on this aspect, attempts were made to develop an artificial diet for the rice leaf folder.

Initially eight known diets developed for important lepidopteran pests were evaluated in 25 altered composition in 10 experiments. These diets were originally developed for *Chilo partellus* (SIDDIQUI & CHATTERJI, 1972), *Heliothis armigera* (NAGARKATTI & PRAKASH, 1974), *Mythimna separata* (NEELGUND & MATHAD, 1979), *C. suppressalis* (KAMANO, 1971), *Sesamia inferens* (QURESHI *et al.*, 1972), *C. polychrysa* (KALODE *et al.*, 1970), *Ostrinia nubilalis* (ISA & KHADR, 1973) and *Scirpophaga nivella* (WAHID & AKHTAR, 1971). Though the original composition of the above diets was maintained in the present study, wherever host plant product was specified, it was replaced with same amount of rice leaf pieces/powder. Ten to thirty neonate and/or second instar larvae were released on each of the diets formulated and the observations on larval survival and percentage pupation were recorded.

Results of these probe experiments showed that none of the test diets except two (*C. partellus* and *C. polychrysa* diets) were suitable for rearing *C. medinalis* larvae. On rest of the diets, neonate larvae did not survive beyond 5 days while second instar larvae survived for 5 to 10 days though none pupated. On the other hand, on *C. partellus* diet supplemented with rice leaf (15 and 30% by wt), 5 to 6 per cent second instar larvae completed development and pupated on *C. polychrysa* diet in original composition (KALODE *et al.*, 1970) three per cent of the larvae completed development. In general, rice leaf powder was found to be an essential component as diets lacking it showed poor growth.

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TABLE 1. Composition of the meridic diet for rice leaf folder, *C. medinalis*.

Ingredient	Quantity (g)
Rajma (*Phaseolus vulgaris*) seeds	100.0
Casein	10.0
Sucrose	20.0
Ascorbic acid	2.0
Brewer's yeast	15.0
Sorbic acid	0.65
Formaldehyde	1.0 ml
Agar	6.0
Rice leaf	50.0
Distilled water	375.0 ml

Diet preparation as followed by Kalode *et al.* (1970).

TABLE 2. Larval survival, development duration and per cent pupation of *C. medinalis* reared on meridic diet.

Parameter	larval stage used	
	neonate	II instar
Initial no. released	100	100
Larval survival on		
5th day after release	87	96
10th day after release	65	84
Per cent pupation	37	74
Larval period (days)* (Mean ± S E)	21.3±0.3	20.0±0.2

* at 27.5 ± 3.5°C and 70 ± 10% RH.

Later, *C. polychrysa* diet supplemented with casein and sucrose proved better with 47% second instar larvae completing development as compared with *C. partellus* diet (20% pupation). Nevertheless survival of neonate larvae on former diet was not encouraging. Neonate larvae were observed to be restless on plain surface of diet and rearing containers and often got drowned in thin film of water if moist diet was offered. Such mortality could be overcome by providing a folded filter paper in rearing cups and by releasing larvae in a dried diet. Additionally, shallow furrows were drawn on the surface of diet smeared on the bottom of containers to provide shelter for the larvae. With these changes made in rearing conditions, 37% pupation could be obtained on the diet when neonate larvae were used.

TABLE 3. Pupal weights of *C. medinalis* reared on meridic diet and on rice variety, TN 1.

Reared on	Pupal weight (mg)	
	male mean±S E (No.)	female mean±S E (No.)
Mericic diet	18.9±0.7[a](24)	17.7±0.5[c](19)
TN 1 variety rice	15.0±0.4[b](35)	13.0±0.5[d](20)

Compalison of means (t test): a-b&c-d: $p<0.001$

Composition of this suitable meridic diet is given in Table 1 and larval survival and other parameters recorded while rearing the insect on this diet are give in Table 2. Pupal weights of both the sexes reared on the artificial diet were significantly better than those obtained when the larvae were reared on TN 1 variety rice plants (Table 3). A small colony of *C. medinalis* has been reared through six successive generations on this diet. Further efforts are being made to improve the keeping quality of the diet so that an easy, economic and convenient mass rearing technique could be developed.

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BRIEF COMMUNICATION

BIOCHEMICAL CHANGES IN HAEMOLYMPH OF MUSCARDINED AND HEALTHY LARVAE OF SILKWORM, *BOMBYX MORI* LINN.

G. RAGHAVAIAH, M. JAYARAMAIAH & R. V. KRISHNA MURTHY

Department of Entomology, University of Agricultural Sciences, Bangalore, India 560 065

(Received 14 November 1987)

The infection of fifth instar silkworm larvae with the fungus, *Beauveria bassiana* (Bals) vuil resulted in increase in uric acid content (6.25 to 10.83 mg%) and reduction in ammonia (6.25 to 1.88 mg%) and osmotic pressure (0.70 to 0.60%) of haemolymph with advance in disease development compared to haemolymph of healthy larvae. However, there was no difference in urea level in haemolymph of both healthy and muscardined silkworm larvae.

(Key words: Bombyx mori, Beauveria bassiana, silkworm)

The mulberry silkworm, *Bombyx mori* Linn. is prone to several virulent and infectious diseases like muscardine, flacherie, grasserie and pebrine. Among them, the white muscardine disease caused by the fungus, *Beauveria bassiana* (Bals.) vuill. is one ef the important and earliest known diseases of silkworms. Despite several studies made on this fungus, exact causes for the pathogenicity are not known. Hence, the present study focusses some light on biochemical changes in haemolymph of silkworm larvae infected with *B. bassiana*.

Uric acid, urea and amonia levels in haemolymph of muscardined and healthy fifth instar silkworms (race 'NB 18') were estimated by following the method of OSER (1965) and osmotic pressure by Barger method as suggested by WELSH & SMITH (1961) for every 24 hours untill the death of infected larvae.

The results indicated an increase in uric acid level in haemolymph of both healthy (6.25 to 9.17 mg %) and infected (6.25 to 10.83 mg%) silkworm larvae. But in infected larvae, the uric acid level increased at a much faster rate with advance in age (Table 1), suggesting that urecomia (high uric acid content) has set in in haemolymph of *B. mori* with infection possibly due to impairment of excretory organs.

Urea level increased in haemolymph of both healthy (37.89 to 40.70 mg%) and infected (38.59 to 40.00 mg%) larvae up to fourth day. But it has dropped later in both healthy (31.58 mg%) and infected (32.63 mg%) larvae suggesting that uremia has not resulted with infection.

Ammonia level decreased drastically in infected larvae (6.25 to 1.88 mg%) compared to healthy larvae (5.83 to 4.38 mg%) with advace in age indicating the impairment of amino acid metabolism.

Osmotic pressure of haemolymph of healthy larvae remained constant (0.7%

TABLE 1. Variation in uric acid, urea and amonia in haemolymph of healthy and muscardined fifth instar silkworm larvae.

Days	uric acid (mg %)		urea (mg %)		ammonia (mg %)	
	H	I	H	I	H	I
1	6.25	6.25	37.89	38.59	5.83	6.25
2	6.67	7.50	39.29	41.76	5.00	5.00
3	7.08	7.80	38.53	37.86	4.58	3.75
4	7.50	8.33	40.70	40.00	4.58	3.75
5	9.17	10.83	31.58	32.63	4.38	1.88

H = Healthy laavae I = Infected larvae

NaCl) throughout the period of development of fifth instar as reported by PATTON (1963). On the contrary. it decreased to 0.65, 0.60 and 0.60 per cent on third, fourth and fifth day respectively in diseased worms.

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BRIEF COMMUNICATION

A NOTE ON *STENEOTARSONEMUS FURCATUS* DE LEON (TRASONEMIDAE : ACARI) AS A PEST OF ONION, *ALLIUM CEPA* L. IN TAMIL NADU

M. MOHANASUNDARAM & P. KARUPPUCHAMY

Department of Entomology, Tamil Nadu Agricultural University, Coimbatore, India 641 003

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The tarsonemid mite, *Steneotarsonemus furcatus* De Leon is reported for the first time in India and as a pest of onions.

(Key words: Steneotarsonemus furcatus, Tarsonemidae, onion)

The tarsonemid mite, *Steneotarsonemus furcatus* De Leon has been reported from different parts of the world. In recent Years it has been recorded as pest of several cultivated crops. Lo & Ho (1979) reported this mite to attack rice along with *Steneotarsonemus spinki* in China. This mite has been reported to cause damage to coconut in Malasia (ANON., 1981 & KANG, 1981); in Taiwan (TSEUG & Lo, 1980) and in Mexico (OTERO-COLINA, 1986). The mites were found under the calyees of the nuts and caused banding and scaring of the nuts. The cultivar 'West African tall' was found to be more susceptible than other cultivars. DENMARK & NICKERSON (1981 a, b) recorded this mite to attack *Maranta* sp., *Calathea* sp. and *Paspalum* sp. and made them unfit for marketting by causing striping, browning and eventual death of the foliage by feeding in large numbers from tip downwards before the leaves unfolded. Since large populations of this mite could kill the plants, they recommended 3 properly timed applications of a wettable powder formulation of dienochlor at 3kg/ 500 l of water or single application of aldicarb granules at 1.25 kg/100m².

This tarsonemid mite has been recently recorded in large numbers from an onion crop in Tamil Nadu. The mites were found in the outermost sheath at ground level of the bulbs. No apparent symptoms of feeding due to this mite was noted, but the infested bulbs were lean and thin compared to the uninfested blubs which were more globular and plumpy. This is the first record of this mite from the Indian region and on the onion crop. Further studies on this mite is in progress.

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EFFECT OF MULTIPLE MATINGS ON EGG PRODUCTION IN *GRYLLODES SIGILLATUS* (WALKER) (ORTHOPTERA : GRYLLIDAE)

M. SUBRAMANIAM, M. A. HANIFFA[1] & T. J. PANDIAN[2]

Post-Graduate Department of Zoology, Jamal Mohamed College, Tiruchirapalli, India 620 020

(Received 5 January 1988)

In *Gryllodes sigillatus*, the total egg output observed for a period of 45 days shows about a three fold increse in a female mated once, compared to that of an unmated female. An increase in the number of mating up to four, shows an augmentation in the egg output but further matings have no significant effect. The female, when paired with multiple males shows a still higher rate of egg output; however, the presence of more number of males affects the egg yield possibly due to overcrowding or interruption of female's oviposition behaviour.

(Key words: Gryllodes sigillatus, multiple matings, egg output, oviposition)

INTRODUCTION

Mating in addition to the role of supplying spermatozoa for fertilization, enhances the egg production in many insects such as the milkweed bug *Oncopeltus fasciatus* (GORDON & BANDAL, 1977) and the cricket *Teleogryllus commodus* (LOHER & EDSON, 1973). The observations however, have shown that the egg laying potential between the mated and unmated females differs considerably as seen in the grasshopper *Melanoplus bilituratus* (RIEGERT, 1965), *O. fasciatus* (GORDON & BANDAL, 1967) and the cricket *Plebeiogryllus guttiventris* (BENTUR & MATHAD, 1975). BENTUR & MATHAD (1973) observed an increase in total egg production in *P. guttiventris* when a female was allowed to mate with several males and a decrease in a female mated several times with a single male. However, information on the effect of multiple matings on egg production is very limited in insects. The present investigation is concerned with the total egg output and number of ovipositions in females mated several times as well as females paired with several males, in the house cricket *Gryllodes sigillatus* (Walker).

MATERIALS AND METHODS

Adult unmated females were selected and divided into 2 series, the first one was used to determine the role of successive matings by a single male and the second one, for pairing by a number of males. Seven groups of females, each containing a minimum of six individuals (in separate containers) of the first series were allowed to mate with a male 0, 1, 2, 3, 4, 6 and 8 times respectively. The test individuals of the second series consisting of seven groups were allowed to pair with 0, 1, 2, 3, 4, 6 and

[1] Post-Graduate and Research Department of Zoology, St. Xavier's College, Palayamkottai, India 627 002.

[2] Department of environmental Physiology School of Biological Sciences Madurai Kamaraj University Madurai, India 625 021.

8 males respectively, throughout the experimental duration of 45 days. The number of matings in the first series and the different number of males retained with the test females in the second series as mentioned above were selelcted for convenience. Small plastic vials containing moist soil were placed inside the containers, for egg laying. The eggs laid were collected and counted for each oviposition. The total egg output and number of ovipositions for the test individuals were calculated.

RESULTS

The observations showing the egg producing potential of female *G. sigillatus* as a result of multiple matings by a single male as well as several males are presented in Tables 1 and 2. Unmated female oviposited 539 eggs in 45 days and the number of ovipositions was 20, with an average of 25 eggs per oviposition. This reveals that mating is not obligatory for either egg production or oviposition in this species. However, a single mating which lasts for about 3 to 4 minutes, augmented the total egg output to 1451. This is slightly 2½ times of what was recorded for an unmated female. Similarly, the number of ovipositions increased to 29 (about one and a half times more) and the mean eggs per oviposition to 50 showing a two fold increase (Table 1). In females which were mated 4 times (each mating lasted for about 3–4 minutes), the total egg output increased to 2355, the number of eggs per oviposition to 75 and the oviposition frequency to 30. Subsequent increase in matings upto 8 times failed to produce any further significant increase in either the total egg output or the number of eggs per oviposition or the oviposition frequency.

With the increasing number of males present per female, the total egg yield as well as number of ovipositions increased from 2504 eggs and 33 ovipositions in a female reared with a single male to 2979 eggs and 36 ovipositions in a female reared with 3 males (Table 2). Similarly, the mean number of eggs per oviposition also increased from 75 to 82. Further increase in the number of males per

TABLE 1. Effect of number of matings on egg output in *G. sigillatus*.

Number of matings	number of ovipositions	total egg output	eggs per oviposition
0	20 ± 1.0	539 ± 91.7	25 ± 6.0
1	29 ± 1.5	1451 ± 167.4	50 ± 8.2
2	30 ± 1.5	1624 ± 130.8	55 ± 7.4
3	31 ± 2.5	2068 ± 123.0	66 ± 2.9
4	30 ± 2.0	2355 ± 163.8	75 ± 9.4
6	33 ± 2.1	2292 ± 141.8	70 ± 3.6
8	32 ± 1.5	2328 ± 101.1	72 ± 7.1

Each value represents mean of six observations.

TABLE 2. Effect of number of males on egg output in *G. sigillatus*.

Number of males preseet	number of ovipositions	total egg output	eggs per ouiposition
0	20 ± 1.0	539 ± 91.7	25 ± 6.0
1	33 ± 2.9	2504 ± 180.8	75 ± 3.7
2	35 ± 2.5	2692 ± 105.1	78 ± 5.1
3	36 ± 2.5	2979 ± 94.5	82 ± 7.0
4	37 ± 1.0	2852 ± 125.0	79 ± 3.2
6	36 ± 2.5	2371 ± 141.6	65 ± 1.4
8	34 ± 1.0	2300 ± 138.0	68 ± 3.1

Each vnlue represents mean of six observations.

female led to a decline in the egg output as well as mean number of eggs per oviposition. For instance, a female attended by 8 males oviposited 34 times, releasing 2300 eggs, with the mean number of eggs per oviposition being 68. The results show that the total egg output is higher in a female reared with 3 males, suggesting that this is the optimum number for an enhanced egg production. Further increase in the number of males reduces the total egg output.

DISCUSSION

The effect of mating in enhancing the eggg output in females has been shown in several species of insects (GORDON & BANDAL, 1967; ENGELMANN, 1970; DELVI & PANDIAN, 1971; LOHER & EDSON, 1973). The results obtained in the mating experiments in *G. sigillatus* indicate that not only the egg output but also the oviposition frequency increases several folds in the mated females as compared to the unmated females. In addition, multiple matings of the single female has also resulted in the increase of egg output. However, the optimum number of matings for an increased egg yield was found to be four. An enhanced egg count in the female *G. sigillatus* was also found, if a single female is kept with more than one male. The experimental results however, indicated that an optimum number of three males has resulted in the maximum egg-count in the female. This suggests that a limited number of multiple matings may be a necessary stimulus for rapid egg maturation and ovulation, in addition to serving as a stimulus for oviposition as seen in *Atteva punctella* (TAYLOR, 1965) and *Rhodnius prolixus* (PRATT & DAVEY, 1972). That the number of males held in higher densities (more than three or four) with a single female diminishes the egg laying potential in *G. sigillatus* suggests that overcrowding of the males or interruption of female's oviposition dehaviour by the males decreases the egg output. The effect of crowding on reducing the egg laying potential has been reported in *Cryptolestes ferrugineus* (SMITH, 1966).

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ANATOMICAL, MORPHOMETRICAL AND HISTOLOGICAL ABERRATIONS IN THE FEMALE REPRODUCTIVE ORGANS OF *CHRYSOCORIS STOLLII* WOLFF (HETEROPTERA, PENTATOMIDAE) AFTER JUVENOID TREATMENT ON THE IMAGINES

B. MUKHOPADHYAY, N. ROYCHOUDHURY & S. CHAKRVORTY

Entomology Laboratory, Department of Zoology, University of Kalyani, Kalyani, India 741 235

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Derangements induced by hydroprene (ZR-0512 or Altozar) and methoprene (ZR-0515 or Altosid) in the female reproductive organs of *Chrysocoris stollii* Wolff were manifested as deformities in the anatomy, morphometry and histoarchitecture when the compounds were topically administered to 0-6 h old imagines. Hydroprene was found to be more effective than methoprene. The derangements showed the possibility of reducing the reproductive potential of the bug.

(Key words : anatomy, morphometry, histology, female reproductive organs, hydroprene, methoprene, *Chrysocoris stollii)*

INTRODUCTION

Potentiality of WILLIAM's (1967) "third generation pepticides" or juvenoids in inducing developmental, structural and functional derangements in the adult female reproductive systems has been studied previously only in a few representatives of Coleoptera (MARUTHI RAM *et al.*, 1982 in *Cylas formicarius*), Lepidoptera (CHAKRAVORTY *et al.*, 1986, ROY CHOUDHURY & CHAKRAVORTY, 1986; in *Corcyra cephalonica*), Thysanura (ROHDENDORF, 1975 in *Thermobia domestica*) and Heteroptera (MASNER, 1967 in *Pyrrhocoris apterus*; REVATHY *et al.*, 1979, 1982 in *Dysdercus koenigii*). In the present investigation an attempt has been made to study the effects of hydroprene and methoprene on the anatomy, morphometry and histomorphology of the female reproductive organs of the imagines of the bug *Chrysocoris stollii* Wolff (Heteroptera, Pentatomidae).

MATERIALS AND METHODS

Freshly emerged bugs of *C. stollii* were obtained from the laboratory stock culture (DEB *et al.*, 1983). The juvenoids hydroprene (Zoecon, ethyl 3, 7, 11-trimethyl-2, 4-dodecadienoate) and methoprene (Zoecon, isopropyl-11-methoxy-3, 7, 11-trimethyldodeca-2, 4-dienoate) were applied topically with a microlitre syringe in acetone solution on the ventral side of the abdomen of 0-6 h old freshly emerged female at the dosages of 200μg and 100 μg per insect. Each individual received 1 μl of the solution. The control insects received 1 μl of acetone only. The treated and control individuals were released into the rearing cages containing their natural food, i. e., green croton plants bearing fruits. Both treated and control insects were sacrificed when they were 2-day old and 10-day old. The female reproductive system was dissected in insect Ringer's solution. A minimum of 10 individuals were sacrificed for morphometrical and

histological observation, following the procedure of CHAKRAVORTY & ROYCHOUDHURY (1986). Measurements were recorded at the maximal dimension of particular structure. The morphometrical data were subjected to analysis of variance.

RESULTS

Normal development: Ovary was distinct in late penultimate instar nymph. The female reproductive system and the histomorphology of ovariole (Fig. 1) was basically similar to those of other heteropterans (JALAJA & PRABHU, 1976; DESHPANDE & SRIVASTAVA, 1981).

Effects of juvenoids: Hydroprene and methoprene could induce noteworthy anatomical, morphometrical and microstructural derangements in the female reproductive organs in 2 day old and 10-day old imagines of *C. stollii*. The abnormalities were more or less similar with both the juvenoids.

On the anatomy: The important anatomical abnormalities were: ovarioles short, thin; germarium and vitellarium deformed or ill developed. In a few cases spermatheca was short. In most cases the number of vitellogenic oocytes was reduced.

On the morphometry: It was found from the data (Table 1) that hydroprene and methoprene treatments caused a reduction of the length and breadth of different parts of female reproductive organs. Length of oviduct, however, increased significantly. In other characters like breadth of oviduct only hydroprene treatment differs significantly in 2-day old specimens but both hydorprene and methoprene treatment differed from control in 10-day old specimens. In regard to the length of spermatheca, there was no significant difference between hydroprene and methoprene treatments as compared to the control. There was however significant difference between hydroprene and methoprene treatments as compared to the control in respect of breadth of spermatheca in 2-day old but the difference was not signifieant in 10-day old specimens. The dosage effect was significant in the case of hydroprene treatment.

On the histology : No histological abnormality could be noticed in the ovary of 2-day old treated bugs. But the following derangements were recorded in 10-day old ovary : deformed germarium, central accumulation of ooplasm in the previtellogenic and vitellogenic oocytes (Fig. 2), presence of vacuoles in the ooplasm of previtellogenic oocytes (Fig. 3), ooplasm started shrinkage (Fig. 4), loosely arranged malformed follicle cells covering the oocyte (Fig. 5), central accumulation of yolk spheres (Fig. 6) and there was either total absence or presence of only very few vitellogenic oocytes with yolk spheres.

DISUSSION

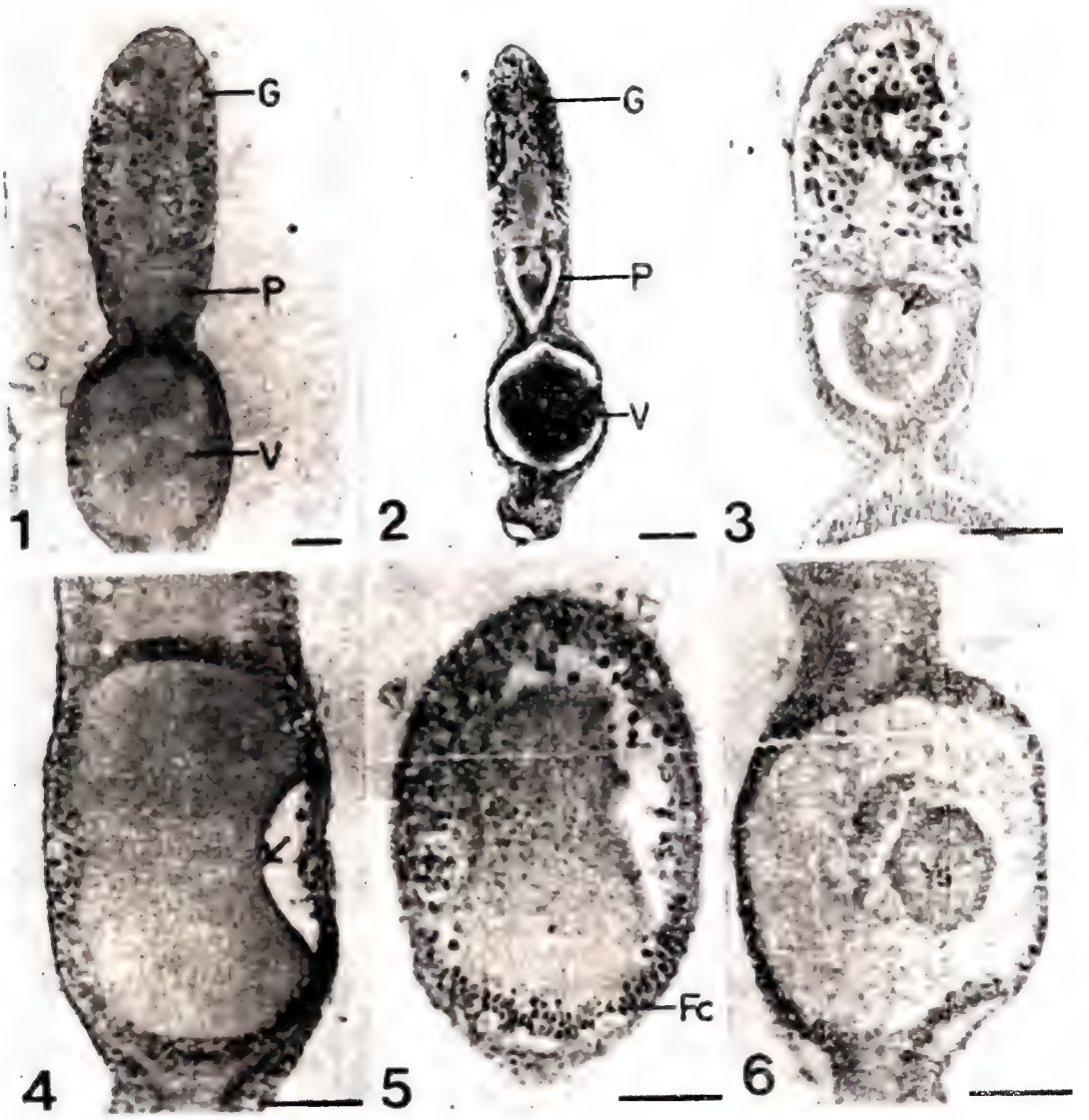
The derangement in the female reproductive system observed in the present investigation show the deleterious effects of hydroprene and methoprene on the reproductive capacity of the imagine of *C. stollii*.

The anatomical and histological aberrations caused by hydroprene and methoprene resemble those reported for some other heteropteran insects (MASNER, 1967; REVATHY et al., 1979, 1982). The occurrence of such abnormalities may be due to changed internal milieu which is normally maintained by an extra-ovarian process under the control of juvenile hormone (NIJHOUT & RIDDIFORD, 1974). Earlier workers (WELLINGTON & MEALZER, 1967; PATTERSON, 1971) have

TABLE 1 Measurements (Mean ± SE) in mm of different parts of female reproductive organs obtained after hydroprene and methoprene treatments on 0–6 h old freshly emerged *C. stolli* (A) in 2–3day old imagines and (B) in 10 day old imagines

Treatment	Dose (µg ind.)	treatment indices	ovariole length	ovariole breadth	oviduct length	oviduct breadth	spermatheca length	spermatheca breadth
Hydroprene	200	t_1	1.83 ± 0.22 (1.5 – 2.0)	0.12 ± 0.04 (0.1 – 0.2)	0.89 ± 0.09 (0.8 – 1.0)	0.24 ± 0.05 (0.2 – 0.3)	2.09 ± 0.15 (2.0 – 2.5)	0.50 ± 0.03 (0.4 – 0.5)
	100	t_2	2.16 ± 0.24 (1.8 – 2.8)	0.13 ± 0.04 (0.1 – 0.2)	0.73 ± 0.07 (0.6 – 0.8)	0.37 ± 0.08 (0.3 – 0.5)	2.14 ± 0.02 (2.0 – 2.5)	0.51 ± 0.03 (0.5 – 0.6)
Methoprene	200	t_3	1.90 ± 0.15 (1.5 – 2.0)	0.12 ± 0.04 (0.1 – 0.2)	0.78 ± 0.12 (0.7 – 0.9)	0.32 ± 0.07 (0.2 – 0.4)	2.16 ± 0.22 (2.0 – 2.5)	0.49 ± 0.03 (0.4 – 0.5)
	100	t_4	1.92 ± 0.23 (1.5 – 2.5)	0.15 ± 0.05 (0.1 – 0.2)	0.70 ± 0.07 (0.6 – 0.8)	0.41 ± 0.07 (0.3 – 0.5)	2.16 ± 0.18 (2.0 – 2.5)	0.51 ± 0.03 (0.5 – 0.6)
Control (Acetone)		t_5	2.33 ± 0.31 (2.0 – 2.8)	0.19 ± 0.03 (0.1 – 0.2)	0.62 ± 0.07 (0.5 – 0.7)	0.46 ± 0.04 (0.4 – 0.5)	2.30 ± 0.28 (2.0 – 2.9)	0.60 ± 0.10 (0.5 – 0.8)
C D of t_1, t_2, t_5 at 1%			0.419	0.050	0.102	0.069	NS	0.046
5%			0.310	0.037	0.075	0.051	NS	0.034
C D of t_3, t_4, t_5 at 1%			0.367	0.052	0.164	NS	NS	0.088
5%			0.271	0.038	0.121	NS	NS	0.065
B								
Hydroprene	200	t_1	2.52 ± 0.48 (2.0 – 3.0)	0.33 ± 0.04 (0.3 – 0.4)	1.06 ± 0.05 (1.0 – 1.2)	0.42 ± 0.07 (0.3 – 0.5)	2.46 ± 0.18 (2.1 – 2.8)	0.48 ± 0.07 (0.4 – 0.6)
Methoprene	200	t_2	2.82 ± 0.31 (2.3 – 3.0)	0.36 ± 0.04 (0.3 – 0.4)	0.98 ± 0.07 (0.9 – 1.1)	0.50 ± 0.06 (0.4 – 0.6)	2.71 ± 0.21 (2.5 – 3.0)	0.57 ± 0.07 (0.5 – 0.7)
Control (Acetone)		t_5	4.26 ± 0.35 (3.8 – 5.0)	0.45 ± 0.05 (0.4 – 0.5)	0.76 ± 0.09 (0.6 – 0.9)	1.04 ± 0.09 (0.9 – 1.2)	3.07 ± 0.06 (3.0 – 3.2)	0.93 ± 0.07 (0.8 – 1.0)
C D of t_1, t_2, t_5 at 1%			0.509	0.121	0.125	0.120	NS	NS
5%			0.377	0.089	0.088	0.085	NS	NS

C D = Critical difference; NS = Non significant; range values are inside parentheses



Figs. 1—6 Longitudinal sections through the ovarioles of 10-day old imagine of *C. stolliu*. 1 Control showing germarium (G), previtellogenic (P) and vitellogenic oocyte (V); 2. Effect of 200 μg of hydroprene treatment showing deformed germarium (G) and central accumulation of ooplasm in a previtellogenic (P) and vitellogenic oocytes (V); 3. Effect of 200 μg of methoprene treatment showing deformed germarium and vacuoles (arrow) in the ooplasm of a previtellogenic oocyte; 4. Effect of 100 μg of hydroprene treatment showing ooplasm started shrinkage (arrow) in a vitellogenic oocyte; 5. Effect of 100 μg of methoprene treatment showing shrinkage of ooplasm and loosely arranged malformed follicle cells (Fc) covering the vitellogenic oocyte; 6. Effect of 100 μg of hydroprene treatment showing central accumulation of yolk spheres (Ys) in vitellogenic oocyte. (Scale bar = 100 μm).

also observed ovarian malformations when juvenoids are applied during the period of yolk deposition. Juvenoids have been found to adversely affect the differentiation of oogonia and follicle cells in some other insect species (ROHDENDORF, 1975; MARUTHI RAM *et al.*, 1982; CHAKRAVORTY *et al.*, 1986; ROYCHOUDHURY & CHAKRAVORTY, 1986). YARAGAMBLIMATH *et al.* (1978), however, have reported that juvenoid application in the adult stage does not affect oogenesis in *Gryllodes sigillatus*, because ovarian differentiation takes place prior to adult emergence.

Our morphometrical data show that hydroprene is more effective than methoprene in reducing the length and breadth of different parts of female reproductive system. This indicates that the potentiality of juvenoids differs. This might be due to the selective binding of hydroprene and methoprene to different protein fractions of heamolymph (TURUNEN & CHIPPENDALE, 1981) and possibly also due to the different kinetics of degradation and excretion of two juvenoids (WEIRICH & WREN, 1973).

On the whole, the derangements produced in the adults after hydroprene and methoprene treatments indicate the possibility of reducing the reproductive potential of the female bugs.

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A NEW SPECIES OF GENUS *NOMIA* LATREILLE FROM INDIA (HYMENOPTERA : APOIDEA : HALICTIDAE)

ABHIRAJ SINGH & V. K. TIWARI[1]

Parasite Multiplication Unit, 50/20, Gangenahalli Layout,
R. T. Nagar P. O., Bangalore, India 560 032

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Nomia (curvinomia) ludhianiensis n. sp. from Ludhiana, (Punjab), has been described, and compared with *Nomia (curvinomia) iridescence* Smith. The present paper contains *ludhianiensis* n. sp. got justified to sub-genus *curvinomia* Michener 1944 on the basis of following combination of characters: malar space absent, body not testaceous; head and thorax black in some cases greenish or bluish; ocellocular distance more than the ocellar diameter; basitibial plate of female broad, round and complete; pronotum without lamella; inner hind tibial spur uniformly serrate, metasomal terga with apical integumental bands of enamel like blue, green, yellow or rarely white and without hair bands; metanotum and soutellum normal; propodeum with basal area defined and slopping in contrast to rest of the area which is vertical as seen in profile.

(*Key words*: Genus *Nomia*, new species)

Prior to this work *Nomia (curvinomia) iridescence* Smith occupied a short para in Fauna of British India (Bingham 1897). This species was first reported from Bhatinda, Ladowal, Punjab, India, by Smith 1858. Bingham C. T. (1897) reported the same species from Burma and Tenasserin; later on Michener 1965, also collected it from the same region. This sub-genus was described by Michener 1944 from North America, Mexico, China, Taiwan, Phillipine Islands, India, Sri Lanka and Africa. Many other species placed under this subgenus are required to be mentioned here: *andrenina* Cockerell 1911, from Chapra, India and Karachi, Pakistan; *aureobalteata* Cameron 1902, from Bengal, India; *bahadur* Nurse, 1904, from North India; *basalis* Smith 1875, from Sri Lanka; *capitala* Smith 1875 from Sri Lanka and North India; *chaprensis* Cockerell 1920, from Chapra, India; *collina* Cameron 1908, from Mt. Abu, India; *clypeata* Smith 1875 from Burma; *combusta* Smith 1875, from Bombay, India; *carinata* Smith 1875 from Burma and Tenasserin; *comperata* Cockerell 1912, from Nasik, India; *fervida* Smith 1875, from North India; *floralis* Smith 1875, from Calcutta, India, Burma, China; *fulvineris* Cameron 1907, from Bombay, India; *himalayana* Nurse 1902, from North India, *iridescence* Smith 1858, from Bhatinda, Ladowal, India; *kangrae* Nurse 1904, from Kangra valley, India

Species description: *Nomia (curvinomia) ludhianiensis* n. sp.* *Holotype* : Female (Agra College, Agra) : Paratypes : 8 females (Agra College, Agra) both types from Ludhiana, (Punjab), India, collected from *Luffa cylindrica*. Fam:Cucurbitaceae).

[1] Department of Zoology, Agra College, Agra. U. P. India, 282 002.

* After the place District. Ludhiana (Punjab) India where author collected the specimens.

General characters: Head and thorax coarsely, abdomen minutely & densely punctate. Integument black, legs and ventral surface of abdomen ferrugineus. Pubescence lacking; clypeus, side of face, surpraclypeal area, genae, pronotum, scutum, scutellum and abdominal segment 1-5 at their margin with yellow enamel like markings.

Head: Inner margin of eyes parallel convergent below; clypeus convex, coarsely punctate, black with yellow band at apical margin, apical margin slightly arched; supraclypeal area dark black with yellow transverse markings, coarsely punctate and convex; paraocular carina dark brown, line not separated from eyes; subocellar surface elevated, with yellow band below lateral ocelli; antennae with median flagellar segments equal in length and width, ferruginous in colour; vertex brilliantly polished black and coarsely punctate; ocelli in a curve on the vertex; ginae elevated, shining dark black yellow band; occipital margin carinate; mandible dark brown, broad at base and tapering towards tip, dorsal groove narrow.

Mesosoma: Scutum black, coarsely punctate, anterior margin with yellow band, median line in the form of a groove, parpsidal line distinct; pronotal lobes small, yellow, smooth; scutellum black, sparsely punctate with mid dorsal yellow band, in profile elevated than scutum; posterior margin of scutellum arched towards metanotum; metanotum brownish black, longitudinally striate, without pubescence, lateral extension posterior to the base of hindwing deeply excavated: propodeal triangle steeply truncate, dark castaneous brown and minutely punctate.

Marginal cell of fore wing longer terminating roundly towards wing margin, submarginal cells three first and third subequal second and third each receiving a recurrent vein beyond the middle, wing colour flavo-hyline, veins testaceous; tegulae small, round, smooth, impunctate, brilliantly polished, testaceous.

Legs: Coxa of fore legs laterally broad, ferruginous, smooth, without hairs; trochanter smaller than coxa, coxal expansion not overlapping the trochanter; femora long, stout, dark brown with pale yellow hairs, smooth and flattened; tibiae dorsolaterally broad, thin towards basitarsus, ferruginous in colour and densely covered with pale yellow hairs; basitarsus and tarsus ferruginous in colour covered with yellow glittering hairs; mid legs characters are similar to fore legs except size, sclerotization and hairs which are much dense; hind legs identical to mid legs except basitibial plate round apically, uncarinate, tibial spur serrate, posterior tibia with scopa of pale yellow hairs.

Metasoma: Basal tergum with a transverse impressed line, pregradular area black, minutely and closely punctate, without hairs, basal margin medially with a pit; gradular line in the form of an elevated ridge in the middle of tergum, slightly light in colour; post-gradular area dark black with brownish tint, brilliantly polished minutely and finely punctate; equal in middorsal length as pre-gradular area, apical margin carinate with enemal like yellow band.

Terga second to sixth; pre-gradular area identical to basal tergum except medially overlapped by proceeded terga; gradular line more prominent on second and third terga, becomes less prominent on successive terga and divides the terga into two equal parts; post gradular area dark black, shining, minutely and closely

punctate and more robust apically, apical margin carinate with transverse bands of yellowish colour.

Genitalia: Quadrate plate small, roughly triangular, the apical end articulates with the arm of sting blub through broad triangular fulcral plate; stylet long and narrow; sting bulb small, nearly funnel shaped; palp appendages small, basally much narrow but apically broad having long setae.

*Measurements** Total length (from base of antennae to metasomal apex) 144 lines (3.6 mm) Head : ratio of median length (from median ocellus to clypeal margin) to maximum width of face (between outer linings of eyes) 26:34. Eyes: length and lateral width 20 : 12, ratio of upper middle, and lower inter spaces 20 : 20 : 18, clypeus median length, basal and apical width 14 : 8 : 12 antennal sockets : distance to clypeus to eye to median ocellus and to each other 6:6:8:6. Antennae relative length of scape 10, pedicel 2, flagellus 20 and width of flagel lar segments 2 : lateral ocelli : distance to eye to occipital margin and to each other 6 : 12 : 4 : labrum : median length basal width and apical width 6 : 6 : 8 : mandible maximum length in dorsal view 12, width at the base 4 : scutum : length and maximum width 22 : 22 : scutellum : median length of dorsal surface 6 : relative length of forewing's submarginal cells, first, second and third 9 : 5 : 7 : relative median with of terga I–V 12 : 8 : 14 : 14 : 12.

Relative affinities: Relative aspects of *Nomia (curvinomia) ludhianiensis* n. sp. stands only with *iridescence*, in following respects : Clypeus black, convex, coarsely punctured : clypeus with yellow bands (no yellow bands on clypeus in iridescence), apical margin slightly arched and weakly carinate (transverse and strongly carinate in *iridescence)* : palp appendages not much larger, straight, basally narrow but apically broad; mandible broad at base, narrow elongate towards apex.

Scutum smooth, punctate with yellow band; parapsidal line distinct before yellow band; metanotum without pubescence : basitibial plate round, uncarinate but tibialspur serrate; scope of pale yellow hairs; Metasoma with yellow bands.

Measurement of body parts are distinctly differentiable. Therefore, this new species comes closer to *Nomia (Curvinomia) iridescence* Smith.

This species *Nomia iridescence ludhianiensis* n. sp. closely resembles with *Nomia (curvinomia) iridescence* Smith but can easily be differentiated from it by having the following characters : legs and ventral surface of abdomen ferruginous; clypeus convex, black, with yellow band on apical margin and coarsely punctuate in the middle, apical margin carinate and much larger than labrum supraclypeal; area not protuberant.

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* = 1mm. = 40 lines.

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BOOK REVIEW

ALTERNATIVES TO SYNTHETIC INSECTICIDES IN INTEGRATED PEST MANAGEMENT SYSTEMS – PROCEEDINGS OF THE SYMPOSIUM HELD AT MADURAI, March 20—31, 1987. Ed. R. REUBEN, Published by Centre for Research in Medical Entomology, Madurai, 240 pp.

The book comprises the proceedings of the symposium held on 30—31 March 1987 at Madurai, sponsored by Indian Council of Medical Research and Department of Science and Technology, New Delhi. It consists of 28 papers divided into five, sometimes overlapping sections, in addition to the keynote address. The sections include : Chemistry of candidate plant products; Plant products in control of paddy pests, Physiological approach for pest control; Control of Insects of public health importance and Alternative strategies for pest control. It also includes seven resolutions incorporating various recommendations passed by the delegates, and the valedictory address. One striking feature of the papers is that except for those in the section on control of insects of public health importance, almost all the other papers deal with results of laboratory or rarely greenhouse research and very little of field- or farm research. Clearly the book shows that there is a wide gap between the two extremes which needs to be filled up. The various papers in the section on control of insects of public health importance, on the other hand clearly shows how various farm practices lead to increase in insect population of public health importance, and thus stress the need for co-ordination between agricultural and public health activities. Published by the Centre for Research in Medical Entomology (ICMR), P. B. No. 5, Sri. Satya Sai Nagar, Madurai 625 003, the book is not priced. Copies are available free on first come first served basis, from the Director of the Centre. Overseas enquiries should enclose expenses to cover postage for despatch of the book.

V. K. K. PRABHU

A TEXT BOOK OF APPLIED ENTOMOLOGY. Volume I : Methods of Insect Pest Control by K. P. SRIVASTAVA, Kalyani Publishers New Delhi, Ludhiana, 1988, 323 pp. Rs. 41/-

The book consists of twentyeight chapters which include introduction, natural insect pest control, applied control; general methods, insecticides, their mode of action, resistance to insecticides, advantages and hazards of insecticides, insecticide application, antifeedants, attractants, repellants, biological control, entomophagous insects, microbial control, behavioural control, hormonal control, chemosterilants, genetic control, radioactice isotopes and ionising radiations in insect pest control, techniques in pesticide residue analysis and integrated pest management. In addition, it has a short bibliography and a subject index. The book, a paperback, subsidised by Government of India through the National Book Trust at Rs. 41/-, is quite affordable not only to libraries but to individuals as well and deals with general principles of insect pest suppression rather than control of indivividual insect

pests–perhaps this aspect is set apart for volume II—but no hint about it is available in the book anywhere. The author is perhaps correct in pointing out in the preface that no book published so far gives all the principles involved in insect pest suppression in a single volume, and this is perhaps the most important merit of the book. The book lays considerable stress on principles of insect control and is thus eminently suited as reference book for undergraduate students and as a textbook for postgraduate students of conventional as well as agricultural universities and to medical entomology students. However, there is a comparative dearth of citations to concrete examples and references to species where various principles are discussed, and the tendency is for generalisation. Another defect relates to where recent trends in the pest control are dealt with, where the author fails to stres ssufficiently that these are at a comparatively early stage of research and has not indicated how far these methods have passed into field level application or field level tests. So the student is likely to take for granted that all these methods have already passed into regular farm. practice. There are a few mistakes here and there, even regarding concepts, which would go rather unnoticed in notes but in a book one does not expect. There is often a tendency for the book to become a compilation of notes. These aspects can be easily rectified by the author at the revision stage. However, there is no doubt that the book is a boon to applied entomology students in Indian Universities both convetional and agricultural as well as to medical entomology students, and is easily affordable to individual readers.

V. K. K. PRABHU

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